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U.S. Environmental Protection Agency

Anaconda Regional Water, Waste, & Soils Operable Unit

Technical Impracticability Evaluation Report

Achievement of Arsenic Human Health Standard in Surface Water and Ground Water in the South Opportunity Area of Concern

September 2011

Montana Department of Environmental Quality

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Final
Technical Impracticability Evaluation Report
Achievement of Arsenic Human Health Standards in Surface Water
and Ground Water in the South Opportunity Area of Concern
Anaconda Regional Water, Waste, & Soils Operable Unit
Anaconda Smelter NPL Site
Anaconda, Montana

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Acronyms and Abbreviations

ADLC	Anaconda-Deer Lodge County
AMC	Anaconda Minerals Company
AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
ARWW&S	Anaconda Regional Water, Waste, & Soil
As	arsenic
As (III)	arsenite
As (V)	arsenate
Atlantic Richfield	Atlantic Richfield Company
AWQC	aquatic water quality criteria
bgs	below ground surface
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGWA	controlled ground water area
COCs	contaminants of concern
CPMP	community protective measures program
CSM	conceptual site model
CWCCIS	Civil Works Construction Cost Index System
cy	cubic yards
DPS	Development Permit System
DEQ-7	Montana Department of Environmental Quality Bulletin 7
EC	electrical conductivity
EPA	U.S. Environmental Protection Agency
FWP	Montana Department of Fish, Wildlife & Parks
FWS	U.S. Fish & Wildlife Service
FS	feasibility study
gpm	gallons per minute
ICs	institutional controls
LRES	Land Reclamation Evaluation System
MCA	Montana code annotated
μg/L	micrograms per liter
MDEQ	Montana Department of Environmental Quality
MGD	million gallons per day
mg/kg	milligrams per kilogram
MW	monitoring well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operations and maintenance
ORP	oxidation-reduction potential
OU	operable unit

OW/EADA	Old Works/East Anaconda Development Area
ppm	parts per million
PRB	permeable reactive barrier
PRP	potentially responsible party
RAOs	Remedial Action Objectives
RDU	remedial design unit
RI	remedial investigation
ROD	Record of Decision
TI	technical impracticability
WMA	Waste Management Area
WQB-7	Water Quality Bureau Circular 7
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
µg/L	micrograms per liter
ZVI	zero valent iron

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Section 1 Introduction

This report presents an evaluation of potential remedial alternatives to reduce the concentrations of arsenic in surface water and ground water in the South Opportunity area within the Anaconda Regional Water, Waste, and Soils (ARWW&S) Operable Unit (OU) of the Anaconda Smelter National Priority List (NPL) Site to levels below the federal and State arsenic human health standards of 10 micrograms per liter (µg/L) in surface water and ground water (Figure 1-1). The evaluation was prepared at the request of the U.S. Environmental Protection Agency (EPA) to analyze the technical impracticability (TI) of surface water and/or ground water remediation to support a waiver of the arsenic human health standard in the South Opportunity area. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121 (d)(4)(c) and National Contingency Plan (NCP) 40 CFR Section 300.430 (f)(1)(ii)(c)(3), EPA may invoke a waiver of an applicable or relevant and appropriate requirement (ARAR) if it is determined to be technically impracticable from an engineering perspective to attain compliance with that standard. This report was prepared to provide EPA decision makers a basis to determine whether surface water and ground water remediation to reduce arsenic concentrations below the human health standard is technically impracticable by providing the following information:

- A summary of data collected both prior to and since the ARWW&S OU Record of Decision (ROD) issued in 1998
- A conceptual site model (CSM) for arsenic surface water and ground water contamination in the South Opportunity area of the ARWW&S OU based on existing and available data for surface water, ground water, and soil
- A review of the previous feasibility study and selected remedy
- An analysis of the restoration potential of the site
- An evaluation of an alternative remedial strategy that is technically practicable, protective of human health and the environment, and satisfies CERCLA Section 121 statutory requirements

A companion document, Site Characterization Report South Opportunity Ground Water and Surface Water Area of Concern (EPA 2009), has been prepared which presents the site characterization and conceptual site model in detail. These elements are summarized herein and the companion document should be referred to for a more complete presentation of the data.

1.1 Problem Statement

Widespread impacts from past smelter emissions and smelting waste deposition have resulted in exceedances of the State of Montana arsenic human health standard of 10 µg/L within ground water and surface water in the ARWW&S OU, including the South Opportunity Area of Concern (AOC) (Figure 1-2). The soils in the South Opportunity AOC generally contain elevated concentrations of arsenic near the ground surface, and the levels decrease with depth. Areas of shallow ground water contamination by arsenic are also present over much of the South Opportunity AOC. It is believed that mobility of arsenic is related to application of irrigation water on contaminated soils. Additionally, ground water discharges to surface water causing contamination of surface water by arsenic.

The feasibility of restoring ground water and surface water to their designated beneficial uses was evaluated in a Feasibility Study (EPA 1997a). It was generally concluded that ground water would be restored in 5½ to 28 years following implementation of source controls designated as cessation of irrigation. Additionally, surface water would be restored following a removal action involving tailings deposited along the stream banks of Willow Creek. These actions were designated as the selected remedy for the South Opportunity AOC (EPA and MDEQ 1998).

Based on ground water monitoring conducted for eleven years following partial implementation of source controls (cessation of irrigation), it is apparent that restoration of ground water will not be completed in a reasonable timeframe. Additionally, a better understanding of arsenic loading to surface water has identified sources that will not be addressed by the removal action identified in the selected remedy for surface water.

1.2 Purpose

Because the selected remedy for ground water and surface water in the South Opportunity AOC is not expected to return these media to their beneficial uses in a reasonable time frame, an evaluation was performed to assess the technical practicability of remediating ground water and receiving surface water to achieve the arsenic human health standard. The results of this evaluation are presented in this report.

1.3 Scope

This TI evaluation is limited to achieving the arsenic human health standard. It does not address Montana Department of Environmental Quality Bulletin 7 (DEQ-7) chronic and acute aquatic life water quality standards identified in the ARWW&S OU ROD that are summarized in Section 2 of this report. Those standards remain in effect throughout the Anaconda Smelter NPL Site as final surface water performance standards.

The extent of this TI evaluation is limited to alluvial ground water and connected surface water bodies within the South Opportunity AOC.

1.4 Report Organization

The organization of this report is structured in accordance with the *Guidance for Evaluating the Technical Impracticability of Groundwater Restoration* (EPA 1993). Although the guidance was developed specifically for ground water, the framework for TI decision-making is essentially the same for surface water. The report is organized into the following sections:

- Section 1 provides the problem statement, purpose, and scope of this TI Evaluation Report including the ARARs for which TI determinations are sought.
- Section 2 lists the Selected Remedy, Remedial Requirements, and Performance Standards for surface water and ground water that were identified in the 1998 ARWW&S OU ROD.
- Section 3 provides a brief site description, including physical features and previous site characterization interpretations, and ownership.
- Section 4 presents remedy decisions, and remedial actions, and remedy monitoring data for the South Opportunity area.
- Section 5 presents a conceptual site model based on the site characterization described herein and in EPA (2009).
- Section 6 evaluates the restoration potential of surface water and/or ground water flows that have arsenic concentrations greater than 10 μg/L. The evaluation includes source control, previous actions, routing, retention, and treatment methods. A brief comparison of implementability, efficiency and costs is provided.
- Section 7 evaluates alternative remedial strategies that are technically practicable, protective of human health and the environment, and compliant with ARARs.
- Section 8 summarizes the results of this TI evaluation, including a map showing the aerial extent of where the ground water and surface water TI zone is located.
- Section 9 lists the references cited in this report and includes the data summary reports that form the basis for the conceptual site model and TI evaluation.

A separate, detailed site characterization report was produced in conjunction with this TI Evaluation (CDM 2009). The site characterization report presents the available site data along with the development of the conceptual site model.

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Section 2 ARARs

The overall goal for ground water at the ARWW&S OU is defined in the National Contingency Plan:

> EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When restoration of ground water is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated ground water, and evaluate further risk reduction.

This statement was also the primary remedial action objective identified in the 1998 ROD.

The remedial action objectives for surface water were:

1. Minimize source contamination to surface waters that would result in exceedances of State of Montana water quality standards.

2. Return surface water to its beneficial use by reducing loading sources of COCs (contaminants of concern).

Since the 1998 ARWW&S OU ROD was prepared, surface water and ground water ARARs have changed. At the time of the ROD, the arsenic human health standard for surface and ground water in Montana Circular WQB-7 dated December 1995 was 18 µg/L, and the Maximum Contaminant Level (40 CFR 141.11), was 50 µg/L. Montana Circular WQB-7 has been renamed Circular DEQ-7, and the current version is February 2008. ARARs pertinent to arsenic in surface and ground water are presented below.

For arsenic, the current surface water human health standard is 10 µg/L measured as the total recoverable fraction. The ground water human health standard specified in DEQ-7 for arsenic is also 10 µg/L. No other surface water or ground water quality standards are being considered for waivers as a result of this TI analysis. Both of these standards are identical to the Maximum Contaminant Level (40 CFR 141.11).

A significant percentage of the South Opportunity Area of Concern is a jurisdictional wetland. Executive Order 11990 was identified as an ARAR in the ROD. This ARAR requires EPA to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.

Executive Order 11988, 40 CFR §6.302(b), and the Montana Floodplain and Floodway Management Act and regulations were also identified as ARARs in the

ROD. A portion of the South Opportunity Area of Concern lies within the 100-year floodplain and these floodplain ARARs must be met.

The ROD also identified the Endangered Species Act as an ARAR. The bull trout, listed as threatened, has been identified as present, having potential for occurrence, or having potential habitat in or near the area. Willow Creek and its tributaries are not Bull Trout Core or Bull Trout Nodal Areas (MFISH 2009) nor are they considered to be critical bull trout habitat (USFWS 2005). There are also numerous State ranked species within the area of concern.

In addition, several water quality ARARs must be addressed, such as the implementing regulations for Section 404 of the Clean Water Act (requiring that no discharge of dredged or fill material be permitted if a practicable alternative exists that is less damaging to the aquatic environment) and MCA §75-5-605 (which prohibits the causing of pollution).

Section 3 Site Description

This section of the TI analysis provides an overview of the location, history, and setting of the South Opportunity Area of Concern within the Anaconda Smelter NPL Site.

3.1 Anaconda Smelter NPL Site Background

The Anaconda Smelter NPL Site (the Site) is located at the southern end of the Deer Lodge Valley, near the location of the former Anaconda Minerals Company (AMC) ore processing facilities. These facilities were developed to remove copper from ore mined in Butte from about 1884 through 1980, when the smelter closed. Milling and smelting produced wastes with high concentrations of arsenic, as well as copper, cadmium, lead, and zinc. Millions of cubic yards of tailings, furnace slag, and flue dust were generated, hundreds of square miles of soil were contaminated by airborne wastes, and millions of gallons of ground water have been polluted via wastes and soils. In 1977, AMC merged with Atlantic Richfield Company, who is the primary potentially responsible party (PRP) at the site.

The ARWW&S OU is intended to be the last OU at the Site requiring a remedy decision and will address all remaining contamination and impacts to surface and ground water, waste source areas (e.g., slag and tailings) and non-residential soils not remediated under prior response actions, including the Old Works/East Anaconda Development Area (OW/EADA) and Community Soils OUs. The ARWW&S OU remedy also brings closure to all previous OUs and removal actions including the Smelter Hill OU, Mill Creek OU, and Flue Dust OU. The OU is intended to coordinate land use decisions made by the Anaconda-Deer Lodge County (ADLC) through adoption of a Master Plan and Development Permit System (DPS), land ownership by the PRP (Atlantic Richfield), long-term maintenance of wastes-left-in-place through designation of waste management areas (WMAs), and use of institutional controls (ICs) to support protective engineering remedies in the final ROD.

3.2 South Opportunity Area of Concern

Figure 1-2 shows the boundary of the South Opportunity AOC. The South Opportunity AOC is valley bottom land located within an area generally bounded by Mill Creek to the north, the Streamside Tailings Operable Unit to the east, the Silver Bow County line to the south, and uplands associated with the Mount Haggin Wildlife Management Area and the bedrock aquifer TI Zone to the west.

3.3 Site Setting

The project area is located in an agricultural valley bottom between the bedrock uplands of Mount Haggin Wildlife Management Area and the streamside tailings operable unit (Figure 1-2). Land use in this area includes agriculture (hay production) and grazing with some residential development.

3.3.1 Soils and Vegetation

The South Opportunity area is almost entirely agricultural with the main activities being hay production and grazing. Hay crops are generally grown using dryland or flood irrigation practices with little to no tilling or annual seeding.

According to the site characterization report (CDM 2009), the soil in the South Opportunity AOC generally contains elevated levels of arsenic near the ground surface, and the levels decrease with depth. The arsenic concentrations at the surface are not as high as other areas of the OU, including Smelter Hill and North Opportunity. The South Opportunity area is agricultural, and it is likely that most of the land has been tilled at some time. These agricultural practices blend the soil in the upper 6 to 12 inches, and this is reflected in the arsenic concentrations being similar at all depths up to 10 inches below ground surface (bgs). The arsenic concentrations are much lower below 10 inches bgs.

There is a small difference in arsenic concentrations within and south of the Town of Opportunity. In town, the overall average arsenic concentration in soil is 174 milligrams per kilogram (mg/kg) while the area south of town the average is 250 mg/kg (CDM 2009).

3.3.2 Surface Water Hydrology

Willow Creek, Willow Glen Gulch, Mill Creek, Brundy Creek, and unnamed tributaries lie within the Upper Clark Fork basin (Hydrologic Unit Code 17010201). These streams all flow into the Mill-Willow Bypass (in the Streamside Tailings Operable Unit) and then into Clark Fork River that is formed at the confluence of Silver Bow Creek and Warm Springs Creek (Figure 3-1). Due to flow manipulation resulting from irrigation practices, annual hydrographs for these streams deviate from unaltered mountain streams. The hydrology is discussed further in the following subsections.

3.3.2.1 Willow Creek

Willow Creek is a perennial stream with its headwaters within and adjacent to the OU along the Continental Divide at relatively low elevations. The basin covers approximately 24 square miles. The USGS has monitoring stations at Upper Willow Creek (Station 12323710) and Lower Willow Creek (Station 12323720). These locations are shown on Figure 3-1. Figures 3-2 and 3-3 show the annual average hydrographs for these two locations, as well as annual average arsenic concentrations.

Willow Creek is divided into two distinct reaches. Upper Willow Creek is a headwaters stream consisting of several spring-fed tributaries. These spring-fed tributaries originate in the bedrock ground water TI zone and are moderately contaminated with arsenic. Where Willow Creek enters the southern Deer Lodge

Valley at USGS Gage 12323710, there is a significant loss in flow from streambed seepage and irrigation diversion. During the irrigation season, there is no flow in Lower Willow Creek at the Crackerville Road.

Lower Willow Creek is a stream fed by gains from alluvial ground water discharges through the streambed within the mainstem and small tributaries to Willow Creek. During the irrigation season, Lower Willow Creek is dry above an elevation of approximately 5000 feet and gains approximately 5 cfs of flow where it meets Mill Creek northeast of the town of Opportunity. Significant tributaries include Brundy Creek, which is fed by irrigation return flows and seepage, and an unnamed ditch that is fed by a drain tile that discharges at the northeast corner of the town of Opportunity. Ditches from Mill Creek enter the Willow Creek watershed, and losses from the ditches and flood irrigation cause some ground water recharge.

Ground water discharging to Lower Willow Creek and subsequently impacting Lower Willow Creek surface water is the primary focus of this TI evaluation. Arsenic surface water concentrations and flow discharge data for Upper and Lower Willow Creek are shown on Figures 3-2 and 3-3.

3.3.2.2 Mill Creek

Mill Creek is located along the north boundary of the South Opportunity subarea. Mill Creek is a perennial stream with headwaters in the Pintlar Mountain Range west of the OU along the Continental Divide. The basin covers approximately 42 square miles.

Several important tributaries enter Mill Creek within the OU, including Joyner Gulch, Cabbage Gulch, and Lost Horse Creek. These tributaries have their headwaters within the OU boundaries and are moderately contaminated because they originate from springs in the bedrock ground water TI zone. Although Mill Creek is not the subject of the TI evaluation, it is the primary source of irrigation water within the South Opportunity AOC.

3.3.2.3 Irrigation Ditches

Irrigation ditches occur throughout the South Opportunity area and significantly affect the local hydrology. At least three ditches divert water from Mill Creek, and at least two divert water from Willow Creek. The historic Yellow Ditch formerly carried water and tailings from Silver Bow Creek, but has been significantly altered and now carries water from Mill Creek. (See Figure 3-1).

Two ditches divert water from Mill Creek to the South Opportunity area. The Opportunity Ditch diverts water from the middle reach of Mill Creek and carries water to the Opportunity area where it splits into numerous laterals. Some of the flow enters the Brundy Creek channel and eventually flows into Willow Creek. This ditch operates only during the irrigation season, typically from mid-April to mid-October each year.

The ACM Ditch also diverts water from the middle reach of Mill Creek. Water flows in the ditch to an area south of Willow Glen Gulch where it flows overland within a broad swale until it meets with the natural channel of Willow Glen Gulch. The diverted water flows within Willow Glen Gulch channel until it meets Yellow Ditch where the entire flow is captured. Water is withdrawn from Yellow Ditch for irrigation of lands along Crackerville Road.

3.3.3 Ground Water

The primary ground water resource within the South Opportunity AOC is the alluvial aquifer present over much of the southern Deer Lodge Valley. The thickness of this aquifer ranges from a few feet at the valley fringes to more than several hundred feet in the center of the valley. The alluvial ground water is used extensively for domestic and stock purposes. A portion of the uppermost zone of this aquifer is contaminated with arsenic at concentrations above human health standards. EPA (2009) presents extensive data concerning the lateral, vertical and temporal extent of ground water contamination in the South Opportunity AOC. Ground water concentrations are shown on Figure 3-4.

An important feature affecting ground water is the presence of a series of drain tiles in and around the town of Opportunity. The drain tiles withdraw more than 10 cfs of ground water from the shallow alluvial aquifer and discharges it to surface water in Willow and Mill Creeks (EPA 2009). The locations of the drain tiles are shown on Figure 3-5.

Ground water also occurs in the bedrock west of the South Opportunity AOC. A large portion of the bedrock aquifer lies within a TI zone designated in the ARWW&S ROD (EPA and MDEQ 1998). Within the bedrock TI zone, ground water exceeds the standard for arsenic and the standard has been waived. The relationship between the bedrock and alluvial aquifers has not been investigated in detail, but limited data collected along the railroad in Section 20 at the head of Willow Glen Gulch (See Figure 1-2) indicates that bedrock ground water at the bedrock-alluvium contact is not contaminated by arsenic (EPA 2009).

3.3.4 Wetlands

Detailed wetland delineations were completed in 1993 and redelineated in 1998 (Atlantic Richfield 1999 Appendix F). The Town of Opportunity area was identified as Assessment Area (AA) 11 and the remainder of the South Opportunity AOC being identified as AA11 and AA-12. A portion of the South Opportunity AOC was considered to be in the Streamside Tailings OU and was mapped separately. A map showing jurisdictional wetlands from the 1998 mapping is shown as Figure 3-6.

Table 3-1
1998 Wetlands Delineation

Assessment Area	Jurisdictional Wetlands (acres)
AA10 Town of Opportunity	395
AA11 Mill and Willow Creeks	2,146
AA12 Southeast Scattered Wetlands (includes significant areas outside the South Opportunity AOC)	76 (all outside the South Opportunity AOC)
Total	2,541

Wetlands in AA11 were re-evaluated again in 2005 (Atlantic Richfield 2005a). AA11 was divided into smaller areas including AA-2 South Opportunity Uplands – South Mill Creek Irrigation Ditches, AA11-7 Flood Irrigation & West Fluvial Tailings, AA11-8 Willow Creek & West Fluvial Tailings, and AA11-9 – Son of Blue Lagoon Lower Reach. The boundaries of these areas are shown in Appendix A.

The re-evaluation of AA11-7 found that the boundaries between natural and artificially supported wetlands were not distinguishable and the 1999 delineation was retained. This resulted in a total of 1594.96 acres of jurisdictional wetlands in this assessment area.

The re-evaluation of AA11-8 focused on the riparian zone and did not address the irrigated areas. The 2005 mapping identified 163.60 acres of jurisdictional wetlands.

The re-evaluation of AA1-9 found a reduction in irrigation downstream of Blue Lagoon led to an absence of wetlands in the South Fork Willow Creek area outside the riparian zone. The table shown on the figure in Appendix A indicated a total of 2.16 acres of jurisdictional wetlands in AA11-9; however, the map clearly indicated a much greater acreage on this assessment area.

Wetlands in Opportunity were mapped in 2004 (Atlantic Richfield 2005b), but the delineation was limited to area affected by remedial action which is limited to the banks of Willow Creek.

Although these assessment areas include portions outside the South Opportunity AAOC, essentially all mapped wetlands lie within the AOC.

Table 3-2
2004-2005 Wetlands Delineation

Assessment Area	Jurisdictional Wetland Acres
AA10-1 Town of Opportunity	2.05
AA11-2 South Opportunity Uplands – South Mill Creek Irrigation Ditches	0.88
AA11-7 Flood Irrigation & West Fluvial Tailings	1594.72
AA11-8 Willow Creek & West Fluvial Tailings	163.60
AA11-9 – Son of Blue Lagoon Lower Reach	2.16
Total	1763.41

Overall, the 2004 to 2005 wetland delineations used a combination of accepting previous mapping, new delineations, and in the case of AA10, neither confirming nor re-delineating, the total current wetland acreage in the South Opportunity AOC is not clearly identifiable. The actual wetland area is likely somewhere between the 1999 delineated acreage and the 2004-2005 delineated acreage. The total acreage of the South Opportunity AOC is 6,672 resulting in wetlands occupying between 26 and 38 percent of the AOC.

3.4 Land Ownership and Use

The project area is used for agricultural hay production, grazing, and low density residential. The agricultural portion of the valley is located south of Highway 1 where the parcels tend to be large with few houses. North of Highway 1, the community of Opportunity is a rural town originally platted as 10-acre parcels, and the density has remained low. Some agriculture is practiced in Opportunity including hay production and grazing, but the main land use is residential.

Almost all land ownership in the South Opportunity area is private. Public lands are limited to corridors along highways, and a former school in Opportunity. Land ownership is shown on Figure 3-7.

Section 4 Previous Interpretation, Decisions, and Previous Remedial Action

This section provides an overview of the problem statements, decisions, and previous remedial actions for the South Opportunity AOC and Willow Creek. This summary provides a framework for understanding the decision to move forward with a TI Evaluation.

4.1 Problem Statements and Selected Remedy

4.1.1 Problem Statements from the Feasibility Study

Based on the conclusions presented in the Remedial Investigation (RI) (Atlantic Richfield 1996), the problem statements were presented in the Feasibility Study (FS) (EPA 1997a). Arsenic was addressed as a metal in this FS, so conclusions regarding metals are applicable to arsenic in most cases. The following are selected portions of the original problem statements followed by revisions based on data collected after the RI/FS.

4.1.1.1 Soil

> *"Based on sample results collected during regional soil investigations at the site, widespread metal [and arsenic] contamination in surface soils occurs in portions of the South Opportunity Subarea. The principal source of the metals [and arsenic] in surface soils in this portion of the site is deposition of stack emissions during operations of the smelters at Anaconda."* (EPA 1997a)

This conclusion remains valid based on information presented in the 2009 site characterization report.

4.1.1.2 Surface Water

> *"The probable source of elevated concentrations of arsenic, copper, and lead in this portion [upper] of Willow Creek is runoff of storm events and snowmelt from areas of contaminated soil…. and …groundwater is not considered the primary source of metals [and arsenic] to surface water in the lower stream reach of Willow Creek. The primary sources of metals [and arsenic] in surface water in this portion of Willow Creek appears to be direct contact of surface water with a thin layer of floodplain tailings…"* (EPA 1997a)

> *"…groundwater is not considered the primary loading source of metals to surface water in the lower stream reach of Willow Creek. The primary sources of metals in surface water in this portion of Willow Creek appears to be direct contact of surface water with a thin layer of floodplain tailings located in the streambank of lower Willow Creek, and runoff of storm water and snowmelt*

from deposits of streamside tailings located in this portion of the Willow Creek floodplain."

Based on the data and analysis presented in the 2009 Site Characterization report and briefly summarized in Section 2, these conclusions need to be revised. The probable source of elevated concentrations of arsenic in Upper Willow Creek is discharge of ground water from the bedrock aquifer. The primary source of arsenic to surface water in lower Willow Creek is ground water from the alluvial aquifer. However, this previous interpretation is still valid for copper and lead in surface water.

4.1.1.3 Ground Water

"The primary source of ground water contamination in the subarea is flood irrigation in areas of contaminated soils. Secondary sources of arsenic in ground water in the subarea are elevated concentrations of arsenic (>100 µg/L) in surface water used for irrigating this area and streamside tailings located adjacent to the lower reach of Willow Creek." (EPA 1997a)

"Results of ground water samples collected from the alluvial aquifer at Monitoring Well MW-231 (0.2 to 2.0 µg/L) located adjacent to the upper stream reach of Willow Creek indicate recharge of the aquifer by surface water from Willow Creek is not a source of ground water contamination to the alluvial aquifer in the South Opportunity Subarea." (EPA 1997a)

Based on the data and analysis presented in the 2009 Site Characterization report, these conclusions are valid, but additional detail has been added.

4.1.2 Feasibility Study Alternatives

4.1.2.1 Soil

The following remedial actions were considered for soils in the South Opportunity area within the FS:

- Willow Creek Streamside Tailings area – Remedial alternatives included capping, reclamation, removal, and partial removal. These actions were expected to eliminate or minimize loading of metals to surface water and minimize metals loading to the aquifer.

- Yellow Ditch – Remedial alternatives included capping, soil cover, reclamation, and removal. These actions were expected to eliminate or minimize loading of metals to surface water and minimize metals loading to the aquifer.

- Blue Lagoon – Remedial alternatives included removal and partial removal. These actions were expected to address metals in surface water and soil pore water.

- Sparsely Vegetated Soils – Remedial alternatives included reclamation and partial reclamation. These actions were expected to reduce erosion and minimize loading of metals to surface water. Although the Problem Statement in the FS (EPA 1997a) indicated flood irrigation in areas of contaminated soil as the primary source of ground water contamination, the effects of the proposed actions on ground water were not evaluated.

4.1.2.2 Ground Water

One remedial alternative received detailed analysis in the Feasibility Study (EPA 1997a). The only alternative evaluated for ground water in the South Opportunity subarea was the No Further Action Alternative. This alternative included:

- Source control – Removal actions implemented as a part of the soils remedy including removal or capping of Yellow Ditch berm materials and removal of streamside tailings along Lower Willow Creek. Irrigation restrictions were placed on property in Section 21.

- Monitoring – Long-term ground water monitoring to ensure the selected soil remedy is *"…effective in treating the source of ground water contamination…"*

- Institutional Controls – Prohibition of well drilling.

4.1.2.3 Surface Water

The only alternative evaluated for surface water in the South Opportunity subarea was the No Further Action Alternative for surface water in Yellow Ditch. The No Further Action alternative addressed surface water as follows:

> *"Surface water is a receptor and will be remediated through the alternatives selected for the solid waste source of the surface water contamination."*

This alterative included institutional controls as follows:

> *"Covenants have been placed on the Willow Glen property including irrigation restrictions. Associated water rights previously used for irrigation purposes will now be used for in-stream base flow on Willow Creek. Minor water flows will continue to be conveyed through Yellow Ditch to other water rights holders and used for limited irrigation practices."*

The effectiveness of this alternative was dependent on the effectiveness of the alternatives for soil as described in the FS:

> *"Under this alternative, surface [water] may remain contaminated above the state AWQC* [Ambient Water Quality Criteria]. *Continued dispersion of contaminant would occur if the source remedies are not effective. Therefore, this alternative is only effective in protecting human health and the environment if the solids remedies are successful."*

In addition to the No Further Action alternative, the soil remedial action for the lower Willow Creek streamside tailings was expected to have the following effectiveness:

> "*Partial removal of the Willow Creek SST waste would be effective in minimizing the following potential sources and pathways:*
>
> - *Minimize loading of metals from Willow Creek SST to surface water and in-stream sediment of Willow Creek*"

4.1.3 Selected Remedy

4.1.3.1 Ground Water

The ground water remedy as stated in the ARWW&S Record of Decision (EPA and MDEQ 1998) includes:

> "*EPA and MDEQ expect to return usable ground waters to their beneficial uses wherever practical through achievement of the remedial action goal, within a time frame that is reasonable given the particular circumstances of the site. When restoration of the ground water to beneficial uses is not practicable, (within WMAs and TI zones), EPA and MDEQ will prevent further migration of the plume, prevent exposure to the contaminated ground water, and further reduce risk by minimizing transport of COCs to the bedrock and alluvial aquifers.*"

Specific to Yellow Ditch and the South Opportunity alluvial aquifer plume, the selected remedy includes:

> *The final remedy for this area of concern will address the identified sources of arsenic: impacted surface waters used for flood irrigation, regional soils containing arsenic from aerially-deposited stack emissions, and berm and sediment material containing arsenic along Yellow Ditch. The remedy will address the historic irrigation practices in which surface water in Willow Creek has been transported for flood irrigation in the South Opportunity area. The major components of this remedial strategy are provided below:*

- *"Minimize flood irrigation practices in the South Opportunity area."* Flood irrigation was reduced by approximately 25 percent beginning in 1997. Monitoring at MW-232 shows only a slight improvement in ground water quality.

- *"Implementation of an engineered soil covers over Yellow Ditch."* A portion of Yellow Ditch was sealed off from transporting irrigation water from Willow Creek. Remedial design is under way for the cover. The section of Yellow Ditch north of MW-232 is still used for irrigation.

- *"Rely on natural attenuation and dilution of arsenic in the alluvial aquifer to control the extent and concentration of arsenic and attain the remedial action objective of* *less than 18µg/L in the aquifer."* Since the remedy is not fully implemented, natural attenuation has not yet accomplished the remedial action goal. Based on the trending in MW-232, natural attenuation will not meet the stated objective for a long period of time.

- *"Establish ICs to control access to and use of water within the South Opportunity area*." A Controlled Ground Water Area is being developed that will include the South Opportunity Area of Concern.
- *"Establish a ground water performance monitoring plan."* A draft plan has been prepared, but is not yet approved by the Agencies.

Separate requirements were made for Blue Lagoon that are not pertinent to the South Opportunity arsenic contamination.

4.1.3.2 Surface Water

Recognizing that the source of surface water contamination in Upper Willow Creek was not well understood, the surface water remedy as stated in the ARWW&S Record of Decision (EPA and MDEQ 1998) includes:

"*Conduct mass loading analysis from headwater drainages to determine distribution of loading sources*;" The 2002 mass loading study identified sources in Upper Willow Creek as discharge from the bedrock aquifer. The 2007 mass loading studies identified sources in Lower Willow Creek as discharge from the alluvial aquifer. The purpose of the studies was to identify possible point sources that could be removed.

"If necessary, use non-point source BMPs [Best Management Practices] *in the headwaters area of Upper Willow Creek by employing land reclamation technologies to reduce surface water runoff and transport of COCs to surface water receptors; "* As a result of LRES evaluations, no BMPs are planned in the Upper Willow Creek watershed. The vegetation was determined to be adequate to minimize runoff, and implementation of BMPs would not significantly improve water quality.

"*Remove an estimated 96,000 cy of fluvially deposited tailings along the lower segment of Willow Creek and dispose into a WMA, and backfill, grade and revegetate area as necessary to prevent erosion of fluvially deposited tailings into the surface water in accordance with ARARs. (The estimated total tailings along the lower segment of Willow Creek is 157,000 cy; this scenario is considered a partial removal).*" A remedial action involving soil removal is being designed (CDM 2008). Site-wide actions also include:

"Establish a long-term surface water quality monitoring plan."

"Finalize and implement site-wide storm water management plan."

"Establish a storm water management performance monitoring program."

4.1.3.3 Soil

Aside from discrete waste, including fluvially deposited tailings and Yellow Ditch berms materials, the selected remedy for soil is:

> *"Apply revegetation technologies to establish a self-sustaining assemblage of plant species capable of:*
>
> > *Stabilizing the soils against erosion and minimizing transport of contaminants to surface and ground water in order to meet water quality standards as set forth in Appendix A;*
> >
> > *Maximizing water usage;*
> >
> > *Re-establishing wildlife habitat; and*
> >
> > *Accelerating successional processes."*

LRES (Land Reclamation Evaluation System) evaluations of the South Opportunity area were completed in 2001. The vast majority of this area was delineated by the LRES evaluation as three polygons – FT-022, FT-023, and FT-024 – totaling 2,414.3 acres. The remedy based on the LRES evaluation for all three polygons was Monitor – Well Vegetated. The design justification stated that these polygons supported sufficient vegetation to meet the remedial action objectives of the ROD and that arsenic concentrations in soil were below the recreational/agricultural/open space land use cleanup action level of 1,000 mg/kg for all sampling locations (Atlantic Richfield 2007). These criteria do not consider transport of arsenic from soil to ground water and the effectiveness at reducing loading to ground water is unknown. The final design for Remedial Design Unit 9 - Fluvial Tailings, which encompasses the South Opportunity area, was approved by EPA and DEQ in 2008.

4.1.4 Progress and Effectiveness of Previous Remedial Actions

Remedial actions that were expected to change the degree of contamination at the site include:

1. Minimize flood irrigation practices in the South Opportunity area
2. Implement an engineered soil cover over Yellow Ditch
3. Rely on natural attenuation and dilution of arsenic in the alluvial aquifer to control the extent and concentration of arsenic and attain the remedial action objective of less than 18 µg/L in the aquifer.
4. If necessary, use non-point source BMPs in the headwaters area of Upper Willow Creek
5. Remove an estimated 96,000 cy of fluvially deposited tailings along the lower segment of Willow Creek

6. Apply revegetation technologies to establish a self-sustaining assemblage of plant species

Of the actions listed above, Number 1 was partially implemented and Number 3 was presumed to be occurring. The remaining actions have not yet been implemented. The tailings to be removed are downstream of most of the ground water and surface water contamination identified in the South Opportunity AOC; therefore, implementation of this action will not impact the majority of the AOC.

Partial implementation of the source control measure to minimize flood irrigation practices involved changing water rights used for irrigation in Section 21 to use as in-stream flow in 1997. This changed the moisture conditions near monitoring well MW-232 from being saturated during the irrigation season to an upland condition where water application is limited to precipitation. Additionally, valley wide changes in irrigation were estimated using an irrigate lands inventory conducted in 1961 compared to false-color infrared aerial photography taken in 2005 plus a windshield survey conducted in 2007 (EPA 2009). The overall reduction in irrigation in the South Opportunity area was estimated to be 25 percent (EPA 2009).

Changes in arsenic concentration in the ground water prior to and after the change in irrigation can be seen in wells MW-232 (Figure 4-1) and MW-225 (Figure 4-2). Ground water monitoring from 1992 to 2008 at MW-232 indicates that the degree of ground water contamination may have decreased slightly, but concentrations remain an order of magnitude higher than the ground water standard for arsenic (Figure 4-1). While the arsenic concentrations have decreased somewhat in MW-232, there does not appear to be a long term trend that would result in this well meeting the standard of 10 µg/L arsenic in a reasonable time.

Ground water monitoring at MW-225 showed a decline in arsenic concentrations from 1992 to 2000 with no change since 2000 (Figure 4-2). Since the decline started before alteration of irrigation practices, the two appear to be unrelated at this location. The other monitoring wells in the area with data prior to 1997 show no trends.

These monitoring data are inconclusive regarding the effectiveness of performance of the selected remedy, and cessation of irrigation was only partially implemented. Although irrigation was ceased in the immediate area of MW-232, it lays directly downgradient of an irrigation ditch still in use and the water in the ditch has been shown to contain arsenic. Additionally, the area upgradient of the ditch is flood-irrigated and data from domestic wells have been shown to be contaminated in this area (EPA 2009). There are no monitoring wells which evaluate ground water quality in an area where irrigation was completely ceased.

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Section 5 Conceptual Site Model

This section presents the conceptual site model (CSM) for the source and transport of arsenic in the South Opportunity AOC. The development of the CSM was described in detail in the site characterization report (CDM 2009). The reader is referred to that report for additional detail and background. A schematic of the South Opportunity CSM is shown in Figure 5-1. A flow chart is included as Figure 5-2.

5.1 Primary and Secondary Sources

The primary sources of the arsenic are aerial deposition of arsenic dust and irrigation with water containing arsenic. Historic smelter emissions containing arsenic caused widespread soil contamination, including the soil in the South Opportunity AOC. These smelter emissions are no longer occurring at the site.

Due to the widespread deposition of smelter emissions and historic tillage, the upper several inches of soil are contaminated with arsenic throughout the South Opportunity AOC. The concentration decreases with depth and distance to the south and east. The contaminated soil is a secondary source of arsenic. Since this primary source has been mitigated, the secondary source – contaminated soil - is the important source in the conceptual site model.

Irrigation water is the second primary source of arsenic in the South Opportunity Area of Concern. Irrigation occurs using water from Willow and Mill Creeks, both of which contain arsenic in excess of the human health standard.

5.2 Pathways

5.2.1 Soil to Ground Water

Shallow ground water in the South Opportunity AOC is contaminated by arsenic within areas of elevated arsenic in soil. The contamination mostly occurs at the water table.

In almost all areas within the South Opportunity AOC, the water table occurs below the depth of contaminated soil. Therefore, the contaminated soil is generally not perennially saturated as a result of contact with ground water. Since a major source of arsenic is the shallow contaminated soil, a transport mechanism must exist to mobilize the arsenic from the soil and transfer it to ground water. The likely mechanism is seasonally saturated conditions causing unstable redox conditions which mobilize arsenic to pore water. This water then percolates from the shallow soil surface to ground water. The source of the water includes local precipitation and applied irrigation water. The available data indicate that there is a correlation between historically irrigated areas, wetlands, and elevated arsenic concentrations (EPA 2009). This correlation does not carry north into the Town of Opportunity.

Mobility of arsenic is strongly related to the presence of iron oxides and oxyhydroxides (e.g. Woolson et al., 1971; Duel and Swoboda 1972, Smedley et al. 2002). Arsenic binds to the iron under a range of conditions, but can desorb and become mobile in ground water under reducing conditions. If this were the dominant mechanism of mobilization, there should be a correlation between reducing conductions measured as oxidation-reduction potential (ORP) and arsenic or iron concentrations in ground water. The available data in the monitoring wells in South Opportunity indicate that no such correlation exists. This was also noted in the RI (Atlantic Richfield 1996) based on 1992-1993 data.

The soil is also expected to have significant microbial activity which also can affect arsenic mobility (Oremland and Stolz 2003, Islam et al. 2004, Burnol 2005, Lloyd and Oremland 2006). Bacteria in water can oxidize arsenite to arsenate or convert arsenites from solid to aqueous form during respiration (Oremland and Stolz 2003). Biological arsenic cycling is beyond the scope of any investigations undertaken or contemplated in the South Opportunity AOC.

Although there is a difference in ground water sources between South Opportunity and the Town of Opportunity, the actual line separating the two water types occurs within Sections 15 and 16 (See Figure 3-1 in EPA 2009). The 2007 investigation found that all shallow ground water in this area contained elevated arsenic concentrations regardless of the water type. Therefore, water type or source is not a significant factor in the mobilizations of arsenic from soil to ground water.

The aquifer materials are considered soil and there may be a transfer of arsenic from the soil to ground water. Throughout the ARWW&S OU and at several wells in the South Opportunity AOC, arsenic concentrations in ground water are higher when the water table rises. This may be caused by desorption of arsenic from the aquifer materials as the water rises. Likewise, the arsenic may adsorb to the aquifer materials as the water table falls. Since a source of arsenic is percolation from soil above the water table, arsenic tends to be higher in concentration at the top of the aquifer, and adsorption/desorption is likely active within the portion of the aquifer that is seasonally saturated. Additionally, changing from saturated to unsaturated is expected to also change the oxidation reduction potential which controls, to a degree, the sorption and solution of arsenic.

5.2.2 Soil to Surface Water

Two pathways are identified to transport arsenic from soil to surface water:

- <u>Overland Flow.</u> The mass loading study on Willow Glen Gulch identified that arsenic concentrations increased in surface water flowing through a reach that was not contained in a channel. Water flows overland for several hundred feet from Station WGG-3 to the confluence with the dry channel of Willow Glen Gulch. There was a slight loss in flow in this reach in March 2007, but arsenic increased from 31.6 to 40.7 µg/L.

- Runoff. Storm water runoff from the contaminated soil enters surface water and has caused elevated arsenic and metals concentrations in receiving waters elsewhere in the OU. Few data have been collected on storm water in the South Opportunity AOC, so the importance of this pathway is not known. Based on the very low slopes and the abundance of vegetation, it is not likely that erosion of contaminated soil from the South Opportunity AOC is a major cause of arsenic loading to surface water.

5.2.3 Ground Water to Surface Water

A significant portion of the shallow ground water in the South Opportunity AOC is collected in drain tiles that discharge to Willow Creek. Additional ground water discharges from springs along Willow Creek south of Section 16. It is likely that additional ground water enters the stream in gaining reaches, but this has not been quantified via investigations.

Ground water forms a major portion of the surface discharge in Lower Willow Creek during base flow. Following spring runoff, a portion of Willow Creek at the edge of the valley is dry and the remainder of Lower Willow Creek is entirely comprised of ground water inflow.

Synoptic sampling conducted in 2007 showed that the ground water that enters Willow Creek south of Highway 1 contains elevated concentrations of arsenic and contributes a significant load of arsenic (see Figure 5-3 for sample locations). During April 2007, the load from ground water south of Highway 1 contributed 79 percent of the total arsenic load in Willow Creek (Figure 5-4). During high flow, ground water in this reach contributed 66 percent of the arsenic load (Figure 5-5).

Ground water that enters Willow Creek north of Highway 1 contributes significant flow, but very little arsenic. Ground water from this reach dilutes the surface water resulting in lower arsenic concentrations.

5.2.4 Surface Water to Soil

During the irrigation season, contaminated water from Willow Creek and Mill Creek is diverted and spread on fields using flood irrigation practices. Prior to 1996, approximately 55 percent of the valley was irrigated. If the contaminated water were applied to uncontaminated soil, it is expected that the arsenic would attenuate. Attenuation of arsenic in irrigated soil is documented at other sites in Montana (e.g. Nimick 1998; Jones *et al.* 1999; Keith; 1995).

Since the soil is already contaminated with arsenic, the attenuation capacity of the soil may be significantly reduced or completely consumed. The ground water under major portions of the South Opportunity AOC south of Highway 1 is contaminated, indicating that arsenic is not being attenuated in the soil. Ground water in other areas including the Town of Opportunity is not significantly contaminated, indicating that arsenic from applied irrigation water is being attenuated in the soil.

5.2.5 Ground Water to Soil

As contaminated ground water flows through soil or sediment that is not elevated in arsenic, it is expected that the arsenic will attenuate by adsorbing to soil. This was the basis for the selected remedy for ground water in the South Opportunity subarea. Based on several years of monitoring, attenuation by aquifer materials has not been shown to be effective at removing arsenic from ground water. On this basis, the ground water to soil pathway is considered insignificant.

5.3 Overall Conceptual Site Model

Based on the discussion above, the overall conceptual site model for the South Opportunity AOC can be developed. The elements include:

<u>Primary Sources:</u>

- Smelter (no longer an active source)
- Irrigation water from Mill and Willow Creeks

<u>Primary Pathways</u>:

  - Aerial deposition of smelter emissions (no longer an active pathway)
  - Flood irrigation

<u>Secondary Source:</u>

- Soil contaminated by aerial deposition and/or flood irrigation

<u>Secondary Pathway:</u>

- Soil to ground water by percolation of applied water and precipitation

<u>Tertiary Sources:</u>

  - Contaminated ground water
  - Contaminated surface water

<u>Tertiary Pathways:</u>

- Ground water to aquifer materials (soil)
- Aquifer materials to ground water
- Ground water to surface water

- Surface water flows off site

A descriptive representation of the CSM is presented on Figure 5-1 and a flow chart of the CSM is shown on Figure 5-2. The dominant pathways for movement of contamination in the South Opportunity AOC in irrigated areas south of Highway 1 are as follows:

- Contaminated soil impacts shallow ground water due to infiltration of water. Impacts are greatest where irrigation with contaminated water occurs. Concentrations are highest during high water table conditions.
- Shallow alluvial ground water discharges from drain tiles and springs to form contaminated surface water. Loading is greatest during high water table conditions.
- The contaminated surface water flows offsite into receiving waters.

The dominant pathways for movement of contamination in the Town of Opportunity and possibly in non-irrigated areas of South Opportunity are as follows:

- Contaminated irrigation water or precipitation infiltrates through contaminated soil, and arsenic either attenuates or is diluted by flow of ground water.

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Section 6 Evaluation of Restoration Potential

This TI evaluation involves evaluation of the restoration potential for both contaminated alluvial ground water and receiving surface water. Although the two media are interconnected, the technical impracticability of successful remediation of each medium is evaluated separately because different constraints are involved for each (ARARs, water rights, etc).

Because the source of arsenic in surface water is primarily ground water, the hypothesis is remediation of the ground water will potentially result in remediation of the surface water. The reverse is not true, however; remediation of surface water will not remediate ground water.

This TI evaluation focuses on shallow alluvial ground water and surface water (broadly Willow Creek and tributaries) in the South Opportunity AOC. As will be discussed in subsequent sections, Mill Creek is not included in this TI analysis for surface water. The arsenic contamination in Mill Creek originates in the upland bedrock TI zone and arsenic contamination along the valley bottom is not as significant. A separate TI analysis for surface water in Mill Creek has been completed (EPA 2010).

This section focuses on the development and screening of remedial technologies to achieve the 10 μg/L standard for arsenic in the South Opportunity AOC ground water and in Willow Creek. Those technologies determined to be feasible and consistent with Agency goals are carried forward for further evaluation against the nine criteria of the National Contingency Plan (Section 7).

6.1 Restoration Technology Evaluation

This analysis of the potential to remediate surface and ground water in the South Opportunity area will utilize the CSM to identify sources and pathways that can be controlled. Control of sources and/or pathways can reduce mobility of arsenic and result in restoration of the affected media. For evaluation of treatment methods for arsenic-contaminated surface and/or groundwater, EPA guidance documents for arsenic treatment technologies were consulted (EPA 2002, 2005).

6.1.1 Soil Removal (Primary and Secondary Source Control)

Based on the CSM, one of the primary sources and a primary pathway (smelter emissions) have been eliminated. The secondary source is contaminated soil. Source control of soil contaminated by arsenic is accomplished by removal. Non-removal alternatives (such as covers and capping) are not expected to be effective at controlling the leaching of arsenic by shallow groundwater. The South Opportunity area is used for agricultural hay production, grazing, and low density residential property. The agricultural portion of the valley is located south of Highway 1 where the parcels tend to be large with few houses. North of Highway 1, the Town of Opportunity is a rural community originally platted as 10-acre parcels, and the density has remained low. Much of the area is irrigated, which alters the natural hydrology by creating seasonally sub-irrigated areas where uplands would be expected. Almost all land ownership in the South Opportunity area is private. Public lands are limited to roads. Land ownership is shown on Figure 3-7.

Due to the widespread nature of soil contamination, selective removal would not be effective at controlling mobilization of arsenic from soil to ground water. As discussed in the CSM, there are no “hot spot” areas of extraordinarily high soil arsenic concentrations that correlate with elevated ground water concentrations or loading to surface water. Significantly more site investigation would need to be done to gain the resolution necessary to support selective soil removals.

The land is productive in its current state due to the existing vegetative condition and large contiguous size. The vegetation is well-established and mature. Removal of existing soil and replacement with clean soil would significantly degrade existing vegetation and the land’s agricultural uses until the replacement vegetation matured. The availability of clean soil in the area has been investigated thoroughly due to the application of final covers over the Anaconda Ponds and Opportunity Ponds. Clean borrow in the area generally is very rocky or sandy and requires the addition of organic content to produce suitable growth media. Thus, there is no guarantee that the replacement soil and vegetation would be of the same quality as the existing soil and vegetation. In contrast, the existing soil is high in organic content and already supports agricultural uses (grazing, hay production).

The ARWW&S remedial action objectives (RAOs) for soil are to establish a vegetative cover and to control direct human contact. The existing vegetation is generally good and is used for hay production and cattle grazing – it meets the first RAO without action. The second goal will be met through land use restrictions. To preserve the existing land use, widespread removal and replacement of soil is not a suitable option.

An estimated 26-38 percent of the South Opportunity Area of Concern is a jurisdictional wetland (Figure 3-6). While this designation does not preclude removal, the associated ARARs (discussed in Section 3), make implementation of soil removal more difficult.

A cost estimate was developed for contaminated soil removal for the South Opportunity area. The cost estimate assumed removal of the top 10 inches of soil (consistent with the depth of elevated arsenic concentrations, generally believed to be till depth) across the entire extent of the ground water arsenic plume (see Figure 3-4), in addition to wetland areas in Opportunity and along the South Fork of Willow Creek where arsenic contamination is suspected. Areas occupied by houses, yards, and roads were not included. The affected area is estimated at 3,015 acres, which amounts to over 4 million cubic yards of soil for removal.

Using these volumes, the cost estimate was developed assuming removal of contaminated soils to the Opportunity Ponds, replacement with clean borrow material and organic amendments, and reseeding. Unit costs were based on similar projects at the Anaconda Smelter site. The removal cost was estimated at 190 million dollars (Tables 6-1a and 6-1b, cost backup provided in Appendix B), assuming an adequate volume of clean borrow material and organic amendments would be readily available nearby. However, it has not been demonstrated that an adequate volume of clean soil and organic amendments are available in the area. Transporting these materials over long distances would significantly increase the soil replacement costs.

Because the soil already meets RAOs, the uncertainty of the effectiveness of large-scale removal of soil, and the fact that the large-scale removal would be inordinately expensive with a significant impact to existing vegetation, the remedial action is not reasonable. The following actions are dismissed by EPA as remedial strategies in this instance:

- Significant disturbance of vegetation
- Removal of contaminated soil
- Disruption of wetland or sub-irrigated conditions that support the vegetation

Because the effectiveness of large-scale removal of soil is uncertain, would be inordinately expensive, and would have adverse affects, it is not a viable or realistic strategy, and elimination of this source is not possible, the strategy is not considered further as a method for ground water restoration.

6.1.2 Leaching of Arsenic from Soils to Ground Water (Secondary Pathway Control)

6.1.2.1 Dewatering Contaminated Soils

The main pathways for mobilization of arsenic from the soil source to ground water are the direct contact of ground water with contaminated soil causing leaching and lateral flow of ground water through soil causing mobilization. The rise in the water table is a basin-wide seasonal response to infiltration of snowmelt in spring. In order to disrupt this pathway, the saturation, solubility, or flow must be controlled.

Preventing the contaminated soil from being saturated for long periods may be effective at reducing mobilization of arsenic to ground water. This would require a separation of the water table from the bottom of the contaminated soil. The soil is known to be contaminated to a depth of at least 10 inches. Assuming that the contamination extends to 20 inches would require that the water table be lowered to a depth greater than 20 inches. This action may be technically difficult for such a large, flat area. For example, dewatering trenches have operated along the north and south sides of the Opportunity Ponds for decades. They have been ineffective at maintaining a low water table, as demonstrated by numerous wetlands surrounding the trenches.

On the other hand, the drain tile network under the Town of Opportunity has functioned well enough to sufficiently lower the water table in the area. Arsenic concentrations from water in these drain tiles are below the human health standard. At first glance it appears these drains have achieved the separation between contaminated soils and ground water, reducing contamination. However, it is believed that it is not solely the separation between ground water and contaminated soils that results in these lower arsenic concentrations, but rather a combination of factors primarily the large flux of ground water in the area that dilutes arsenic concentrations (EPA 2009).

Seasonal irrigation is a mobilization pathway of lesser importance. Because application of arsenic-contaminated irrigation water is a source of arsenic contamination to the soils, it is possible that an irrigation ban or irrigation with uncontaminated water could be mandated. However, mass loading studies did not show a correlation between irrigation return flows and increases in arsenic concentrations in Willow Creek (EPA 2009). The area immediately surrounding MW-232 was irrigated until 1997 and contained standing water during the irrigation season. This area now exhibits upland conditions. Ground water monitoring from 1992 to 2008 at MW-232 indicates that the degree of ground water contamination may have decreased slightly, but concentrations remain an order of magnitude higher than the ground water standard for arsenic (see Figure 4-1). Ground water monitoring at MW-225 showed a decline in arsenic concentrations from 1992 to 2000 with no change since 2000 (see Figure 4-2). Since the decline started before alteration of irrigation practices, the two appear to be unrelated at this location. The other monitoring wells in the area with data prior to 1997 show no trends. Therefore, the effectiveness of such a ban is highly uncertain.

Based on the above discussion, it appears that the effectiveness of widespread dewatering of surface soils, either through dewatering trenches or irrigation bans would be uncertain. Furthermore, this alteration may adversely affect the quality of the vegetation in the area, particularly jurisdictional wetland areas.

Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300.430), EPA analyzes and compares remedial action alternatives using nine evaluation criteria (two threshold criteria, five balancing criteria, and two modifying criteria). That analysis of alternatives reflects the scope and complexity of site problems and alternatives being evaluated and also considers the relative significance of the factors within each criterion. The nine criteria are part of the National Contingency Plan (40 CFR 300.430(e)(9)). The last two criteria, referred to as modifying criteria, consider state and community acceptance of the remedy. Early in the South Opportunity remedial design process, EPA considered implementing a ban on irrigation in the area beyond the reductions made in 1997 to attempt to minimize arsenic loading to ground water. Local government, as well as area landowners, expressed opposition to this alternative. The South Opportunity area has been used as agricultural land since the 1860s. The local community stated their desire to EPA that they wish the area to remain in agricultural production, maintaining the rich historical heritage of this portion of the southern Deer Lodge

Valley. The local government also expressed opposition to the possible takings of landowner water rights. In light of these concerns, EPA has eliminated additional irrigation bans from consideration for further analysis.

6.1.2.2 Arsenic Immobilization

Solution of arsenic can be affected by the addition of dissolved iron, which will co-precipitate with arsenic to a less soluble form. Conceivably, a solution of dissolved iron (such as ferric chloride) could be added to the soils in South Opportunity to immobilize the arsenic. Addition of the iron would require large quantities of low pH solution (commercially produced ferric chloride has a pH of less than 2) to be applied over the entire area of shallow ground water and contaminated soil. The solution would quickly neutralize on contact with the soil, and the iron would co-precipitate with the arsenic leaving a less mobile form of arsenic in the soil.

While the technology has merit, there are serious limitations. Application of sufficient quantities of solution over 10 square miles of land that includes wetlands would be challenging and expensive. More importantly, application of a low pH solution would devastate the existing vegetation. Application of iron in solution is not considered a viable remedial strategy.

6.1.2.3 Control of Ground Water Migration

Assuming that source control is not implemented and the leaching pathway remains, any potential remedial action will address ground water contamination after it has become contaminated. The general approach to remedial action then becomes the collection and treatment of ground water. Because ground water becomes contaminated within the area of shallow ground water and contaminated soil, no effort should be made to collect the ground water under these conditions: Removal of the contaminated water will result in replenishment from adjacent ground water that will then become contaminated upon prolonged contact with the soil. Instead, collection could be accomplished using an interception trench along the downgradient edge (i.e., along the gaining reaches of Willow Creek) to prevent lateral movement and discharge to Willow Creek. The water from the interception trench would then be routed to a treatment plant. Alternatively, a low permeability slurry wall could be constructed to prevent contaminated ground water from entering Willow Creek. Ground water behind the slurry wall would then be pumped to a treatment plant.

Collection of contaminated ground water along Willow Creek would prevent loading of arsenic from ground water that currently occurs. Following treatment, the water would be placed into the stream to maintain current discharge conditions. However, while this would decrease surface water concentrations, it would not necessarily result in compliance with surface water standards within Willow Creek. Upper Willow Creek (Station 12323710 Willow Creek near Anaconda) arsenic concentrations are typically in the 15-20 μg/L range, which already exceeds the 10 μg/L standard before it enters the South Opportunity AOC. (See Figure 3-2).

Because ground water collection would be conducted only at the margins of the contaminated area, widespread ground water contamination would remain. Movement of the contamination could be controlled by collection at the perimeter, but the vast majority of the contamination would remain. As previously stated, collection of ground water within the area of contaminated soil would result in recontamination of water that flows in to replace the collected water. Because source control (soil removal) is not viable, the ground water contamination would remain indefinitely.

No further general approaches are available that would disrupt the mobilization of arsenic from soil to ground water nor involve major disturbance of soil or vegetation but are scalable to this site. In the absence of controlling leaching of arsenic from soil, the ground water throughout the South Opportunity area will remain contaminated. As the ground water flows out of the area by reporting to surface water, it is recharged by ground water from an upgradient source that becomes contaminated due to leaching as it flows through the contaminated soil. If a ground water collection system is implemented, the recharged water will become contaminated in the same way as current conditions, leading to treatment in perpetuity.

Because source control and pathway control are not viable remedial alternatives, remediation of the ground water is technically impracticable, and ground water in the South Opportunity area will remain contaminated indefinitely.

6.2 Surface Water Remedial Strategies and Simplifying Assumptions

6.2.1.1 Reaches with Ground Water Gain

Most surface water reaches within the South Opportunity area gain ground water. The only way to prevent the surface water from becoming contaminated in these streams is to remediate the ground water. The potential for ground water remediation was discussed in Section 6.1.2. For the purposes of this section, the ground water is assumed to remain contaminated, and the surface water in gaining reaches will also remain contaminated. Thus, the only practicable method of collecting surface water is within the stream channel after it has discharged from the ground. This would leave all surface water above each collection point as contaminated.

6.2.1.2 Surface Water Collection System and Flow Rates

All surface water could be collected using conventional diversion structures and transmitted to a treatment plant. Since no ideal location prevents all surface water contamination, collection should occur downstream of all gaining reaches, but prior to exiting the OU.

In order to provide passage for aquatic life in Willow Creek, the diversion structure would be designed to return treated water immediately below the diversion and include a channel or raceway around the diversion through which fish can freely move.

Since the surface water flow is almost entirely derived from ground water gain in the South Opportunity area, the treatment flow rates for the surface diversion or ground water collection alternatives are essentially the same. The annual average discharge for downgradient Willow Creek at Opportunity (Station 12323720) is 7.88 cfs. Therefore, for cost estimation, the treatment plant will be sized for 8 cfs with year-round operation. This assumes storage would be built to hold higher flows for treatment during lower flows of the year. At this flow rate, a peak storage capacity of about 2,000-acre-feet would be required. At 5-feet-deep, this is about 400 acres.

6.2.1.3 Ground Water Collection System and Flow Rates

Collection of ground water immediately prior to its entry into the stream prevents the surface water from becoming contaminated. Because the aquifer is extensive, collection of contaminated water at the top of the aquifer would induce flow of cleaner water from deeper in the aquifer to replace the collected water. Ideally, the cleaner water would then form surface water in the gaining reaches and surface water would meet standards. Collection of all the ground water along the gaining reaches would cause a drop in the water table and a corresponding reduction in gain to surface water. In order to balance the system, treated water would be returned to surface water to recreate the gaining reaches. This is considered a surface water remedial action because the primary purpose is to be protective of surface water. This ground water collection could be constructed along all gaining reaches in order to be protective of surface waters in the South Opportunity AOC.

For this scenario, ground water would be intercepted along Willow Creek prior to its emergence as surface water. Further investigation would be required to determine the quantity and quality of water to be collected and treated, but an estimate can be made based on the known gain in the surface water. The average ground water gain during base flow conditions between the Upper and Lower Willow Creek stations is approximately 4 cfs. For costing purposes, the ground water treatment plant will be sized to treat 5 cfs.

However, as previously discussed, this alternative would only address contaminated ground water entering surface water within the South Opportunity AOC. Upper Willow Creek (Station 12323710 Willow Creek near Anaconda) arsenic concentrations are typically in the 15-20 μg/L range, which already exceeds the 10 μg/L standard before flowing into the South Opportunity AOC. (See Figure 3-2).

6.3 Evaluation of Potential Technologies for Arsenic Treatment in Surface and Ground Water

6.3.1 General Arsenic Treatment Chemistry

Arsenic is typically found in two different oxidation states: arsenite, As (III) and arsenate, As (V). The more oxidized arsenate is typically found in surface water, while in ground water, arsenite is often found. In aqueous solutions, arsenite exists in solution as a neutral molecule, while arsenate exists as an anion. Because arsenite is uncharged, it is more difficult to remove from aqueous solutions than arsenate. A review of the existing data indicates that arsenic speciation of the surface waters around the ARWW&S OU site is not known in detail; however, some arsenic speciation data from MW-232 indicated arsenic was primarily in the reduced form. Because much of the arsenic in South Opportunity is transported via exfiltration of contaminated ground water, it is reasonable to believe that some fraction of the arsenic is in the arsenite form.

Treatment of arsenic is typically accomplished using iron oxyhydroxides to adsorb and/or co-precipitate arsenic. Arsenic can be removed from water using a variety of processes including ion adsorption, activated alumina adsorption, ion exchange, reverse osmosis, nanofiltration, lime softening, iron and alum coagulation, and coagulation-assisted microfiltration (French 2005, EPA 2002).

Two categories of treatment strategies were screened for evaluations: passive treatment vs. active treatment. Each of these technologies is discussed below.

6.3.2 Passive Treatment

6.3.2.1 Retention/Detention

Retention/detention of surface water entails routing of surface water to a location where the water is held for a period of time before discharge (detention), or to be held indefinitely to allow for infiltration/evaporation (retention) of the water. Detention/retention basins are typically used for storm water runoff to allow suspended solid materials to settle instead of being discharged to the stream. This passive treatment method is not expected to be effective for dissolved arsenic because there are no solid particles to settle. Furthermore, based on the site conceptual model, construction of detention/retention ponds is analogous to flood irrigation and may enhance arsenic mobility. Thus, this passive treatment technology is not retained for evaluation.

6.3.2.2 Treatment Wetlands

Engineered wetlands have been used for passive treatments of metals-impacted waters. Typically these wetlands facilitate bacterial sulfate reduction to generate hydrogen sulfide, which then precipitates with heavy metals to form insoluble metal sulfide precipitates. However, facilitating metal-sulfide precipitation treatment chemistry is not applicable for arsenic removal to low concentrations. The minimum solubility of arsenic sulfide minerals is approximately 45 parts per million (ppm), which is orders of magnitude higher than regulatory standards. Furthermore, if reducing conditions are present, arsenic can be reduced from As (V) to the more mobile, uncharged As (III) redox state. Instead of sequestering arsenic, these systems have the potential to mobilize arsenic out of substrates (Gammons and Frandsen, 2001). It is possible that saturated, organic rich micro-environments throughout the South Opportunity area may be facilitating reducing conditions and contributing to arsenic mobilization. Creating more of these micro-environments could further exacerbate the problem.

Arsenic can be removed in an oxidizing wetland environment. Dissolved iron is oxidized to form an iron hydroxide precipitate and adsorb arsenic. However, dissolved iron is not available to any significant degree in South Opportunity ground water, so this option would not work without supplemental iron. Utilizing iron oxidation over a large area would be difficult and would result in orange precipitates, which could hydraulically clog any passive system. Due to these difficulties in dosing and dealing with iron sludge, such iron adsorption treatment chemistry is better facilitated in an active treatment plant (as evaluated in the following active treatment subsections).

Because arsenic is not removed in anaerobic treatment wetlands and because of difficulties in facilitating the iron-adsorption removal mechanism in a passive system on such a large scale, passive treatment wetlands are not a viable treatment alternative for arsenic at this site.

6.3.2.3 Permeable Reactive Barriers

Permeable reactive barriers (PRBs) are installed across the flow path of a contaminated ground water plume, allowing ground water to flow through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing agents within the wall such as zero-valent metals, chelators, sorbents, and microbes. The contaminants are either degraded or retained in a concentrated form by the barrier material, which may need to be replaced periodically.

Zero valent iron (ZVI) has been shown to be an effective PRB material for removal of arsenic (ITRC 2005, Man-Chi Lo et al. 2006). The arsenic removal mechanisms are complex and are thought to consist of adsorption (most likely onto iron corrosion products such as iron oxyhydroxides), precipitation as an iron-arsenic or arsenic sulfide mineral, co-precipitation (incorporation of small amounts of arsenic in carbonate "green rust" or iron sulfides), and redox transformation (Man-Chi Lo et al. 2006).

Conceptually, a continuous PRB capable of transecting all shallow ground water flow along gaining reaches of Willow Creek would be constructed (see Figure 6-1). Under this scenario, a PRB consisting of a 50 percent feldspar sand and 50 percent ZVI mixture is envisioned (for cost estimation only). The feldspar sand (instead of quartz sand) helps to buffer against the high pH levels generated by the ZVI. Because the arsenic contamination is only found in the shallow portion of the ground water, the PRB would only need to intercept and treat the top ten feet of the aquifer. As the high arsenic water flowed through the PRB, the arsenic would be removed before flowing into Willow Creek. It would be critical for the permeability of the PRB to be significantly higher than the rest of the aquifer to ensure ground water flows through the PRB and not around or under it. It is not feasible to tie the PRB to an impermeable bedrock confining layer because the alluvium is up to hundreds of feet deep.

PRBs using ZVI to treat arsenic contamination are still in their developmental stage. Some pilot scale work and limited full-scale applications have been conducted (IRTC 2005). One recent pilot scale PRB installation at the Asarco East Helena smelter site has been reported to successfully treat arsenic. Preliminary results indicate that arsenic concentrations as high as 20 mg/L in ground water entering the PRB are reduced to concentrations to near or below 10 µg/L within the barrier (EPA 2008). These arsenic concentrations are orders of magnitude greater than those found in South Opportunity ground water.

Long-term effectiveness of the PRB may be decreased due to precipitation of metals, reduced areas of reactivity, biofouling, and competition for reactive sites. All of these actions lead to loss of porosity and reactivity (Bronstein 2005). Innovative technologies for barrier regeneration are under development, such as flushing of the wall or ultrasound technology to mobilize the precipitates and allow them to pass through the wall (EnviroMetal Technologies, Inc. 2007). With the exception of potential permeability loss, the passive nature of the barrier results in negligible operations and maintenance (O&M).

Because PRBs constructed of ZVI have been successful in removing arsenic at other sites, this alternative is retained for evaluation.

6.3.3 Active Treatment

Arsenic is typically found in two different oxidation states: arsenite, As (III) and arsenate, As (V). The more oxidized arsenate is typically found in surface water, while in ground water, arsenite is often found. In aqueous solutions, arsenite exists in solution as a neutral molecule, while arsenate exists as an anion. Because arsenite is uncharged, it is more difficult to remove from aqueous solutions than arsenate. A review of the existing data indicates that arsenic speciation of the surface waters around the ARWW&S OU site is unknown; however, because much of the arsenic is from exfiltration of contaminated ground water, it is reasonable to believe that some fraction of the arsenic is in the arsenite form.

Treatment of arsenic is often accomplished using iron as a co-precipitant. Based on United States Geological Survey (USGS) data, dissolved iron in Lower Willow Creek is generally present at less than 100 µg/L, which is near the detection limit. Iron concentrations in ground and surface waters in South Opportunity are too low to effectively co-precipitate arsenic. Treatment of arsenic would likely require the addition of iron for co-precipitation. Technologies such as adsorptive media, coagulation/filtration, and ion exchange are best suited for sites with relatively low arsenic levels in their source waters (EPA 2005).

Treatment of arsenic is not necessarily simple. Frequently, water treatment processes target other contaminants of concern, but some arsenic is removed via adsorption/coprecipitation with the targeted contaminants. For example, in a lime precipitation treatment process, some arsenic will be polished from the water as metal precipitates form, but lime precipitation alone is not considered a reliable treatment technology for arsenic removal. French (2005) summarized arsenic removal technologies as follows:

> *Proven arsenic removal technologies rely on adsorption or ion rejection. Arsenic can be removed from water using a variety of processes including ion adsorption, activated alumina adsorption, ion exchange, reverse osmosis, nanofiltration, lime softening, iron and alum coagulation and coagulation-assisted microfiltration. Because most of these methods rely on ionic charge, As V will be easier to remove than As III in the working pH range of drinking waters, and, therefore, if arsenite is present, pre-oxidation should be the first step.*

Because arsenic concentrations in the surface water are already relatively low, and discharge from a treatment facility would need to achieve the even lower standard of 10 µg/L, the treatment process would need to be highly effective to reach these low concentrations.

Given the large volumes of surface water that would need treatment, the arsenic treatment process used would need to take large flow rates into consideration. Because ion exchange and reverse osmosis processes are typically used for small point-of-use systems, it is assumed these systems would not be appropriate at the flow rates that would be required to treat these surface waters. The analysis in French (2005) states, "*Typically the most economical choice for large volume water treatment is to utilize an iron addition, oxidation and filtration process. The key to success is to have a filter that effectively filters iron, as arsenic removal effectiveness will have a direct correlation to iron removal efficiency.*" An example of the process described is shown in Figure 6-2.

Based on this analysis, active treatment has been selected over passive treatment to develop cost estimates for TI evaluation. It is assumed that the arsenic treatment process would involve oxidation, iron flocculation and adsorption, and then filtration. For oxidation, chlorine or ozone (or some other appropriate oxidant) would be required. Following the oxidation, iron chloride would be added, which would form an iron-oxyhydroxide flocculant. Arsenic would then adsorb to the iron. The iron/arsenic solids would then filter/settle out.

6.4 Treatment Costs

For the PRB and active treatment alternatives, preliminary cost calculations indicated that capital and O&M costs would be very high. Therefore, the cost estimates in the following sections should be considered screening level only. Cost backup information is provided in Appendix B.

6.4.1 PRB Cost

For cost estimation purposes, the PRB was assumed to be a continuous barrier between the Willow Creek crossing at Crackerville Road, downstream to Highway 1, and then parallel to Highway 1 (Figure 6-1). This is the reach with the largest density of saturated soils and springs contributing to Willow Creek. The length was estimated at 15,000 feet, and the depth of active media was 10 feet. Data from project-specific experience and from the literature were used to derive a cost of $201 per square foot (area perpendicular to flow). This assumes a thickness of 3 feet.

Costs are summarized in Table 6-2a. Capital costs are significantly higher for construction of a PRB than for an active treatment plant, but significant savings in O&M costs should be gained. O&M costs are expected to be minimal as long as permeability is maintained in the wall (through proper upfront media selection and careful construction). The ITRC document (2005) notes that no ZVI PRB sites have reached the useful life of the media, so no data exist on which to base O&M. Therefore, ITRC recommends assuming 25 percent of the capital cost every 10 years for O&M.

The capital cost was estimated at $48 million. Using the ITRC recommendation for O&M, the 50-year present value cost (at 7 percent discount rate) is $59 million (Table 6-2b). Because this cost estimate is calculated primarily on length, significant savings may be gained by targeting the areas of highest arsenic loading. Further investigation would be necessary to identify such areas.

6.4.2 Active Treatment of Willow Creek Surface Water (8 cfs)

The volumes of surface water that would need to be treated in the South Opportunity area are large and are well beyond what would typically be built for remedial action. For many reasons that will be discussed further, it is believed that this cost estimate is conservatively low because significant costs such as sludge disposal, pretreatment, and pumping were not included. The cost estimate was developed assuming there would be one treatment plant with a capacity of 8 cfs (slightly greater than the annual average discharge).

For comparison, a municipal drinking water facility is designed for approximately 80 gallons per person per day. For a small city the size of Butte (33,892 from the 2000 census), this would be 1,883 gallons per minute (or 4.2 cfs).

The cost estimates for surface water treatment were based on project-specific experience as well as EPA literature estimates for arsenic treatment processes. Capital and O&M costs were then scaled up using professional judgment, erring on the conservatively low side. The capital cost estimate of $2,010,000 (1998 dollars) was taken from Table 3-4 for a 1 million gallon per day (MGD) treatment plant (EPA 2002). This capital cost was escalated by a factor of 45 percent from 1998 dollars to 2008 dollars using the U.S. Army Corps of Engineers (USACE) Civil Works Construction Cost Index System (CWCCIS) (USACE 2008). Table 6-3a summarizes estimated capital costs.

Because literature guidance did not have adequate estimates of O&M, project specific experience at the Summitville water treatment plant was used (2006 dollars). The Summitville treatment plant ran for 7 months of the year and treated approximately 1,100 gallons per minute (gpm). The annual O&M and lime treatment costs were scaled up proportional to flow to estimate the annual O&M. For general maintenance (labor, equipment), the cost was scaled by a factor of 1.5. All costs were then escalated from 2006 to 2008 dollars by a factor of 8 percent based on the USACE CWCCIS (USACE 2008).

For chemical costs, it was assumed that lime would not be needed, but that ferric chloride would be needed for adsorption/coprecipitation of the arsenic. Ferric chloride was found to be approximately three times the cost of lime on a per weight basis. As a rough estimate, the lime costs from the Summitville plant were used as a basis, multiplied by a factor of three, and then directly scaled up on a flow basis. These O&M costs are primarily dependent on chemical reagent costs, which are directly proportional to flow rate. Table 6-3a summarizes estimated O&M costs.

For the Willow Creek facility, the capital costs were estimated at $25 million and annual O&M costs were estimated at $6 million dollars. O&M costs are very high due to the very high flow rate. The 50-year present value cost (at 7 percent discount rate) is estimated at $104 million (Table 6-3b).

6.4.3 Active Treatment of Ground Water (5 cfs)

This alternative is nearly identical to the previous active treatment evaluation, except the design flow is based on ground water gain between the Upper and Lower Willow Creek USGS monitoring stations, estimated to be 5 cfs. Thus, all costs dependent on flow rate were adjusted accordingly.

Capital and O&M costs are summarized in Table 6-4a. Construction of the ground water capture system and conveyance is not included in the cost. For the Willow Creek facility, the capital costs were estimated at $15 million, and annual O&M costs were estimated at $5 million dollars. The 50-year present value cost (at 7 percent discount rate) is estimated at $79 million (Table 6-4b).

6.5 Other Considerations

In addition to treatment costs, several other key considerations pertaining to treating surface water flows within the ARWW&S OU impact the practicability of implementing the remedial alternatives. These considerations include conveyance systems, water rights, potential impacts to aquatic life, and impacts to landowner water rights. Each consideration is discussed below. No preliminary costs were estimated for these other considerations.

6.5.1 Routing Considerations

Surface water routing entails strategic diversions of contaminated waters: 1) in order to prevent their discharge to cleaner surface water bodies, 2) for alternate management, and/or 3) for treatment of the waters. Collection of all discharge in Willow Creek is very straightforward, except that a provision would be needed to return treated water in such a manner that the streambed would not be dewatered and aquatic life would not be hindered from moving through the area. Lift stations would also be required to pump the water back to the point of collection for discharge.

6.5.2 Aquatic Life Impacts

Existing data compiled during the Baseline Ecological Risk Assessment (EPA 1997b) and in fish surveys completed by FWP suggest that although occasional exceedances of DEQ-7 aquatic life standards present a potential risk, the ARWW&S OU streams generally support reasonable populations of aquatic organisms. By diverting surface water to a treatment facility, treating the water to reduce arsenic concentrations below 10 μg/L (well below the aquatic life standard of 150 μg/L), and returning the treated water to the point of collection, significant changes in physical and chemical properties of surface water can be expected. These include temperature, dissolved oxygen, and general chemistry (e.g., total dissolved solids would increase due to the addition of chemical reagents such as ferric chloride). The cumulative effects of these impacts on downstream aquatic life are not known and would require analysis before a treatment system could be implemented.

6.5.3 Water Rights

The Upper Clark Fork River basin is closed to new appropriations of surface water. Collection of water for treatment requires a water right, so an exception to the basin closure would be required. Since treatment is a non-consumptive use, it is expected that an exception would be possible with the general requirement that the treated water is returned to the water body from which it was diverted.

The basin closure extends to ground water if the source aquifer is hydraulically connected to surface water. Given that the surface water bodies within the South Opportunity area are gaining streams, the connection is clearly established and the shallow ground water is closed to new appropriations as well.

An additional concern is that the water diverted for irrigation over soils containing elevated arsenic levels would eventually discharge into surface water and cause further exceedance of standards.

6.5.4 Receiving Waters

Surface Water

Surface water in Willow Creek flows into Mill Creek, where the two streams form the Mill-Willow Bypass, which in turn joins Silver Bow Creek and Warm Springs Creek to form the headwaters of the Clark Fork River. Concentrations of arsenic exceed human health standards in Mill Creek near its mouth. Mill Creek also has significantly higher flows than Willow Creek, so little will be gained through dilution with hypothetically cleaner Willow Creek water. Thus, because arsenic concentrations already exceed human health standards in Mill Creek, treating Willow Creek arsenic to human health standards provides very little benefit for receiving waters.

Furthermore, surface water from the Mill-Willow Bypass flows into the Clark Fork River. Figure 6-3 shows a comparison of total recoverable arsenic loads from Willow Creek, Mill Creek, Warm Springs Creek, and Silver Bow Creek as compared to arsenic loads at the headwaters of the Clark Fork River. This graph shows that all of these streams contribute significant arsenic loads to the Clark Fork River. Willow Creek is typically the second or third highest loading source of arsenic in the basin. Hypothetical arsenic concentrations in the Clark Fork River at Galen were calculated assuming flows in Willow Creek were treated down to 10 µg/L or 1 µg/L (Figure 6−4). As these figures show, reducing arsenic loading from the South Opportunity area (Willow Creek) will have little effect on the overall arsenic loading at the headwaters of the Clark Fork River.

Figure 6-5 shows simulated concentrations in Willow Creek for the ground water capture and treatment alternatives (PRB and active treatment of intercepted ground water). Because upstream concentrations in Willow Creek already exceed the 10 µg/L standard (see Figure 3-2), any treated water would need to be treated to less than 10 µg/L to dilute the upstream arsenic concentrations and achieve standards in the mixture. If ground water were treated to 5 µg/L, or even as low as 1 µg/L, in-stream arsenic concentrations in Willow Creek would still exceed 10 µg/L except during low flows (and low concentrations). Thus, while this alternative could greatly reduce arsenic concentrations, it cannot achieve the surface water ARAR in Willow Creek.

Ground Water

In general, contaminated ground water from the South Opportunity area discharges to Willow Creek surface water. Monitoring Well MW-225 just east of Willow Creek was previously contaminated, but showed a decline and now contains only slightly elevated arsenic. This well indicates the water quality exiting the site is slightly below the ARAR (around 6 to 8 µg/L). North of Highway 1, all ground water is relatively low in arsenic. Thus, essentially no arsenic exits the South Opportunity AOC in ground water.

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Section 7 Alternative Remedial Strategy

7.1 Surface Water

As presented in the 1998 ARWW&S OU ROD, the selected remedy for surface water is source controls through land reclamation, selective removal of tailings, engineered storm water runoff controls, and monitoring. This TI Analysis has considered multiple approaches to remediation of the surface water in the South Opportunity area. The proposed alternate remedial strategy for surface water in the South Opportunity Area of Concern includes:

> Institutional controls. Institutional controls (ICs) that are currently being developed will also address potential human consumption of surface water exceeding the arsenic human health standard. Specific Institutional Controls components to address this potential risk include the Community Protective Measures Program (CPMP) and the Development Permit System (DPS). The CPMP includes educational materials such as brochures and periodic newspaper announcements to inform the public about arsenic present in certain surface water receptors, while the DPS will include provisions that prohibit individuals to use surface water as a drinking water source within the Smelter Overlay District.
>
> ARAR Waiver. Waiver of the arsenic human health standard for surface water within the South Opportunity Area of Concern. No other surface water standards are being considered for waivers as a result of this TI analysis. No other waivers are applied as other ARARs will be or have been met.
>
> Monitoring. Surface water will continue to be monitored to ensure compliance with ARARs that have not been waived.

For comparison, two alternatives for surface water restoration are discussed.

Alternative 1: Collection of surface water at a single diversion in Lower Willow Creek. The water would be treated and returned to the surface water immediately below the diversions.

Alternative 2: Collection and treatment of ground water along gaining reaches of Willow Creek. This could be accomplished by collecting and routing ground water to a treatment plant, or by installation of a PRB along Willow Creek. This alternative is a ground water action with the purpose of preventing migration of arsenic to surface water receptors.

7.2 Ground Water

As presented in the 1998 ARWW&S OU ROD, the selected remedy for ground water where restoration of ground water to beneficial uses is not practicable is to: prevent further migration of the plume; prevent exposure to the contaminated ground water; and further reduce risk by minimizing transport of COCs to the bedrock and alluvial aquifers. The proposed alternate remedial strategy for ground water in the South Opportunity Area of Concern includes:

> Institutional controls. A controlled ground water area (CGWA) is being developed for the ARWW&S outside of the South Opportunity area. The CGWA does not currently anticipate an outright well ban, so the details of the ground water controls should be evaluated to see if this is appropriate for the South Opportunity Area of Concern.
>
> ARAR Waiver. Waiver of the arsenic human health standard for ground water within the South Opportunity Area of Concern. No other ground water standards are being considered for waivers as a result of this TI analysis. No other waivers are applied as other ARARs will be or have been met.
>
> Monitoring. Ground water will continue to be monitored to ensure compliance with ARARs that have not been waived.

No ground water alternatives were identified that resulted in remediation of the ground water within the South Opportunity Area of Concern because of the widespread nature of the source. Source control alternatives beyond those already implemented were eliminated during screening. Therefore, all ground water strategies include waiver of the arsenic human health standard for ground water and implementation of institutional controls. Ground water remediation alternatives that prevent discharge of contaminated ground water to Willow Creek are the same as Surface Water Alternative 2 discussed above. Because the contaminated South Opportunity area ground water discharges to surface water, movement of the plume is hydraulically controlled. Therefore, this remedial strategy does not include a separate ground water capture and treatment component to be evaluated.

7.3 Comparative Analysis of Alternatives

In accordance with the National Contingency Plan, the relative performance of each alternative is evaluated using the nine criteria (40 C.F.R. § Section 300.430 (e)(9)(iii)) of the NCP as a basis for comparison. The purpose of the evaluation process is to determine which alternative: (a) meets the threshold criteria of overall protection of human health and the environment and attainment of ARARs, (b) provides the "best balance" with respect to the five balancing criteria of 40 CFR § 300.430(e)(9)(iii)(C)-(G), and (c) takes into consideration the acceptance of the state and the community.

7.3.1 Threshold Criteria

7.3.1.1 Overall protection of human health and the environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

Protection of human health is ensured through a combination of institutional controls and monitoring. All alternatives would leave arsenic in the ground water upgradient of the collection point, so the institutional control would be needed to be protective of human health.

Willow Creek surface water meets aquatic life standards nearly all of the time (see Figures 2-2 and 2-3). One exceedance of the 150 µg/L aquatic life standard for arsenic was measured by the USGS during 5 years of monitoring (164 µg/L). Based on this monitoring record, it is anticipated that aquatic life exceedances will be rare and minor in nature. Aquatic life standards do not apply to ground water.

Existing data compiled during the Baseline Ecological Risk Assessment (EPA 1997b) and in fish surveys completed by FWP suggest that although occasional exceedances of Water Quality Bulletin(WQB)-7 (the predecessor to the current DEQ-7 standards) aquatic life standards present a potential risk, the ARWW&S OU streams generally support reasonable populations of aquatic organisms. By diverting surface water to a treatment facility, treating the water to reduce arsenic concentrations below 10 µg/L (well below the aquatic life standard of 150 µg/L), and returning the treated water to the point of collection, significant changes in physical and chemical properties of surface water can be expected. These include temperature, dissolved oxygen, and general chemistry (e.g., total dissolved solids would increase due to the addition of chemical reagents). The cumulative effects of these impacts on downstream aquatic life are not known and would require analysis before a treatment system could be implemented.

Surface water Alternative 1 would leave arsenic in the surface water above the point of diversion for treatment, so the institutional control would be needed to be protective of human health. Surface water Alternative 1 would not change concentrations in Willow Creek itself; it would only reduce the loading of arsenic from Willow Creek to downstream surface water receptors.

Surface water Alternative 2 (ground water treatment) would also not necessarily achieve the human health standard in Willow Creek. Arsenic concentrations in Upper Willow Creek exceed the human health standard due to contaminated bedrock ground water from the bedrock TI zone. Therefore, any captured and treated ground water would need to be treated to less than 10 µg/L in sufficient quantities to dilute the upgradient surface water so that the mixture met the human health standard. In the case of active treatment of captured ground water, surface water upstream of the treatment plant effluent would not meet the human health standard.

Similarly, treating Willow Creek to meet human health standards would not eliminate exceedances of arsenic in downstream receiving waters (Mill Creek and the Clark Fork River). Calculation of estimated downstream concentrations in the

Clark Fork River if Willow Creek surface water were treated to 10 µg/L showed that the Clark Fork River would still not meet the human health standard (see Figure 6-6).

7.3.1.2 Compliance with ARARs

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d) and NCP 40 C.F.R. §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4), 42 U.S.C. 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking waiver.

The proposed alternate remedial strategy meets all ARARs except the 10 µg/L human health standard for arsenic in surface and ground water (as specified in DEQ-7 and 40 CFR § 141.11).

Surface water Alternative 1 would leave arsenic in Willow Creek surface water in excess of the human health standard. Furthermore, the reduction in loading would not result in achievement of human health standards in receiving waters.

Surface water Alternative 2 (collection and treatment of ground water prior to discharge to Willow Creek) would significantly reduce arsenic loading to Willow Creek and would locally reduce arsenic concentrations. However, the extent of this decrease is uncertain. Subsequent arsenic loads transported to downstream receiving waters would also decrease, but treatment of arsenic in Willow Creek alone will not result in downstream receiving waters meeting the arsenic standard (see Figure 6-4).

None of the alternatives is capable of achieving the human health standard for arsenic with certainty. Therefore, a waiver of the human health arsenic standard is necessary.

7.3.2 Primary Balancing Criteria

7.3.2.1 Long Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

The proposed remedial strategy does not involve implementation of remedial actions. The strategy is limited to administrative actions and institutional controls. These are considered to be very effective and permanent for limiting exposure to arsenic in surface water and ground water

The treatment alternatives rely on active collection and treatment of surface and/or ground water indefinitely. The long-term effectiveness and permanence of treatment alternatives requires a very large commitment to operations and maintenance.

As already discussed, treatment would not result in achieving the human health standard in the receiving waters (Mill-Willow Bypass and Clark Fork River – see Figures 6-4 and 6-5).

7.3.2.2 Reduction in Toxicity, Mobility or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

The proposed alternate remedial strategy does not alter the existing toxicity, mobility or volume of arsenic in surface or ground water in the South Opportunity Area of Concern. Source control through removal or dewatering was not compatible with existing land uses and was unimplementable. The treatment alternatives are effective at reducing the toxicity and mobility of arsenic via capture and treatment. The ground water interception and treatment alternative would contain the ground water plume and prevent migration to surface water, resulting in decreased arsenic concentrations in surface water. However, as was shown in Figure 6-5, upstream sources of arsenic cause Willow Creek to exceed the arsenic standard upstream of the South Opportunity AOC, and treatment of contaminated ground water would not ameliorate this situation.

7.3.2.3 Implementability

The proposed alternate remedial strategy of institutional controls is easily implemented. Waiver of the ARARs can be implemented by EPA through administrative actions.

The treatment alternatives require construction of collection systems and a very large treatment plant, or a very large PRB. While challenging because of the large scale, the treatment alternatives could be implemented.

7.3.2.4 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

There is no construction phase to the proposed alternate remedial strategy, so the short-term effectiveness is the same as the long-term effectiveness.

The treatment alternatives would not be effective until after the completion of full scale collection and treatment facilities. Therefore, the short-term effectiveness is the same as current conditions.

7.3.2.5 Cost

The cost of the proposed alternate remedial strategy has not been quantified, since it adds no additional costs to the existing 1998 Selected Remedy requirements for monitoring and institutional controls. The costs of the treatment alternatives are high, mainly due to the large scale of the impacted area. The treatment plant or PRB capital and 50-year O&M costs were estimated from approximately $59 million to $104 million dollars. Significant costs such as energy and sludge management were not included. The cost of the collection systems was not prepared because it is expected that the treatment plant represents the largest cost.

7.3.3 Modifying Criteria

7.3.3.1 State Acceptance

DEQ concurs in this TI evaluation.

7.3.3.2 Community Acceptance

This TI Evaluation was prepared as an attachment to the ROD Amendment completed in 2011. Public participation for the ROD amendment and this TI Evaluation are identical and is summarized in Section 12 of the ROD Amendment. Generally, interested parties including other agencies and the public were provided with copies of the proposed plan for the ROD Amendment and were given the opportunity to comment on the TI Evaluation during a public meeting and through written comments. Comments were incorporated in the Final TI evaluation as appropriate. A responsiveness summary was prepared as part of the ROD Amendment.

Section 8 Summary and Conclusions

8.1 Ground Water

The CSM in Section 5 showed that the source of arsenic contamination in ground water was the combination of contaminated soil and saturated conditions. The previous remedial actions of reducing irrigation and allowing natural attenuation to work for eleven years has not resulted in significant progress toward meeting the ground water ARAR. Additional remedial actions which would control the source through removal action or changing the hydrologic conditions are difficult to implement because much of the area of concern is a jurisdictional wetland (i.e., a wetland regulated under Section 404 of the Clean Water Act). Additionally, the geochemical conditions necessary for natural attenuation are not present (EPA 2009). Since no actions are available which will remove the source or disrupt the transport pathway, any ground water within or entering the South Opportunity Area of Concern will remain or become contaminated with arsenic. Even if ground water is withdrawn for treatment, the recharge water will become contaminated. Because the contaminated South Opportunity TI zone ground water discharges to surface water (Willow Creek), movement of the plume is hydraulically controlled.

This evaluation concludes that it is technically impracticable from an engineering perspective to reduce arsenic concentrations below 10 µg/L in ground water within the South Opportunity TI zone discussed in Section 8.3. It would be possible to collect and treat ground water just prior to its entry into Willow Creek. Treating ground water at the downgradient edge of the plume would not change the extent, magnitude, or mobility of the ground water plume. This action would benefit the surface water receptors and thus is not a strict ground water remedial action. On this basis, ground water treatment at the edge of the plume is considered a surface water action.

Active collection and treatment of the ground water in the South Opportunity Area of Concern would have very limited benefit due to the inefficacy of collection and treatment of lower arsenic contaminant levels over a significantly large area. Therefore, this evaluation concludes that it is technically impracticable from an engineering perspective, to collect and treat ground water to concentration less than 10 µg/L arsenic at the edge of the contaminant plume in the South Opportunity Area of Concern. The technical impracticability area on this basis is the same as the area wide TI zone shown on Figure 8-1.

8.2 Surface Water

The CSM (Section 5) shows that the source of arsenic in surface water is gains from ground water via small tributaries and drain tiles. An additional source of arsenic in surface water is upstream source within the bedrock TI zone. As discussed in Section 8.1, it is technically impracticable to remediate the ground water throughout the

South Opportunity Area of Concern and a previous determination has concluded that it is technically impracticable to remediate the upstream source.

It is possible to collect and/or treat ground water within the South Opportunity AOC at the edge of the plume where the contamination enters Willow Creek. Discharge of treated water from the ground water treatment system would dilute the surface water in Willow Creek for approximately one mile to its mouth. As shown in Section 6.5.4, this would result in Lower Willow Creek meeting the standard for a portion of the year, but would not result in meeting the standard at all times due to the upstream source. Therefore, the effectiveness of ground water treatment on surface water quality is insufficient to meet the surface water standard for arsenic due to an upstream source.

Collection and treatment of all surface water in Lower Willow Creek to meet the arsenic human health standard would be possible. The sources of arsenic are tributaries, drain tiles and upper Willow Creek. It would be difficult to implement a system where treated water would be returned to all the collection points, thus at least some of the streams reaches or tributaries may be dewatered resulting in severe impacts to aquatic life. Instead, the collection point would be downstream of all sources of arsenic. This would result in tributaries and upstream reaches not meeting the arsenic standard, but would preserve the flow and meet aquatic standards for arsenic. Downstream of the treatment plant discharge, the arsenic standard would be met to the mouth of Willow Creek. Willow Creek combines with several other streams that contain arsenic to form the Clark Fork River. The simulation shown in Figure 6-4 indicates that treatment of surface water in Willow Creek to meet the arsenic standard would not result in the receiving water, the Clark Fork River, meeting the arsenic standard.

This evaluation concludes that because of an upstream source of arsenic contamination, combined with inordinately large treatment costs with very limited benefit, it is technically impracticable from an engineering perspective to reduce arsenic concentrations below 10 µg/L in surface water in the South Opportunity Area of Concern.

As discussed in Section 8, the alternative remedial strategy (source control measures, monitoring, and institutional controls), should the arsenic human health standard be waived, is protective of human health and the environment.

It is uncertain whether surface water arsenic concentrations will eventually be reduced below the human health standard in a reasonable time frame, as required by NCP 300.430(a)(1)(iii)(F). Thus, there is a need for a TI waiver. Because contaminants will remain in place, the TI waiver can be periodically re-assessed by EPA during the five year review.

8.3 TI Zone Boundaries

Surface water investigations conducted in 1993 and 2007 attempted to sample all tributaries to lower Willow Creek. All samples exceeded 10 µg/L arsenic confirming the widespread nature of surface water contamination. Figure 8-1 delineates the South Opportunity ground water/surface water TI zone. The area generally includes the valley bottom land located within an area bounded by Mill Creek or Highway 1 to the north, the Streamside Tailings Operable Unit to the east, the Silver Bow County line to the south, and uplands associated with the Mount Haggin Wildlife Management Area (also the bedrock TI zone) to the west. Downgradient movement of the plume is hydraulically controlled by discharge into surface water either along Willow Creek or drain tiles. Because of the connection between the extent of wetlands and ground water contamination, wetlands on the north side of Highway 1 are included in the TI zone. This area was investigated in 2009 and the downgradient boundary of the plume was confirmed. Wetlands further north are not included in the TI zone because no data have been collected to indicate that shallow ground water contamination exists in that area. Data from drain tiles and domestic wells indicate very low arsenic concentrations in ground water north of the TI zone.

The surface water TI zone includes all surface water, which is connected to ground water, within the ground water TI zone plus all surface water exiting the bedrock TI zone to the confluence of with Mill Creek and Willow Creek. This TI evaluation focuses on the mainstem named streams and named tributaries because the available data are mostly limited to these water bodies. The results of the analysis are extended to include all surface water within the boundaries of the TI zone because the loading sources are continuous and the potential exists for arsenic concentrations to exceed 10 μg/L in surface water throughout the TI Zone. The arsenic human health standard ARAR waiver applies to all surface water within the TI zone.

8.3.1 Surface Water Quantity within TI Zone

The quantity of surface water affected by the TI Zone is measured as a discharge rate or flow. The lengths of stream reaches affected by the TI Zone were calculated by summing the lengths of perennial and ephemeral streams listed in the National Hydrologic Database that lie within the TI Zone.

The total quantity of surface water for which the arsenic human health standard ARAR waiver is sought is estimated to be 9 cfs (the USGS average annual discharge for Willow Creek at Opportunity). The length of the Willow Creek mainstem in the South Opportunity AOC is approximately 5.5 miles.

8.3.2 Ground Water Quantity within TI Zone

The quantity of ground water affected by the TI zone is measured as the area with a total thickness of ten feet. The total quantity of ground water for which the arsenic human health standard ARAR waiver is sought is estimated to have a surface area of approximately 5,517 acres) or a volume of 13,793 acre-feet (assuming an aquifer porosity of 25 percent).

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Section 9 References

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Figures

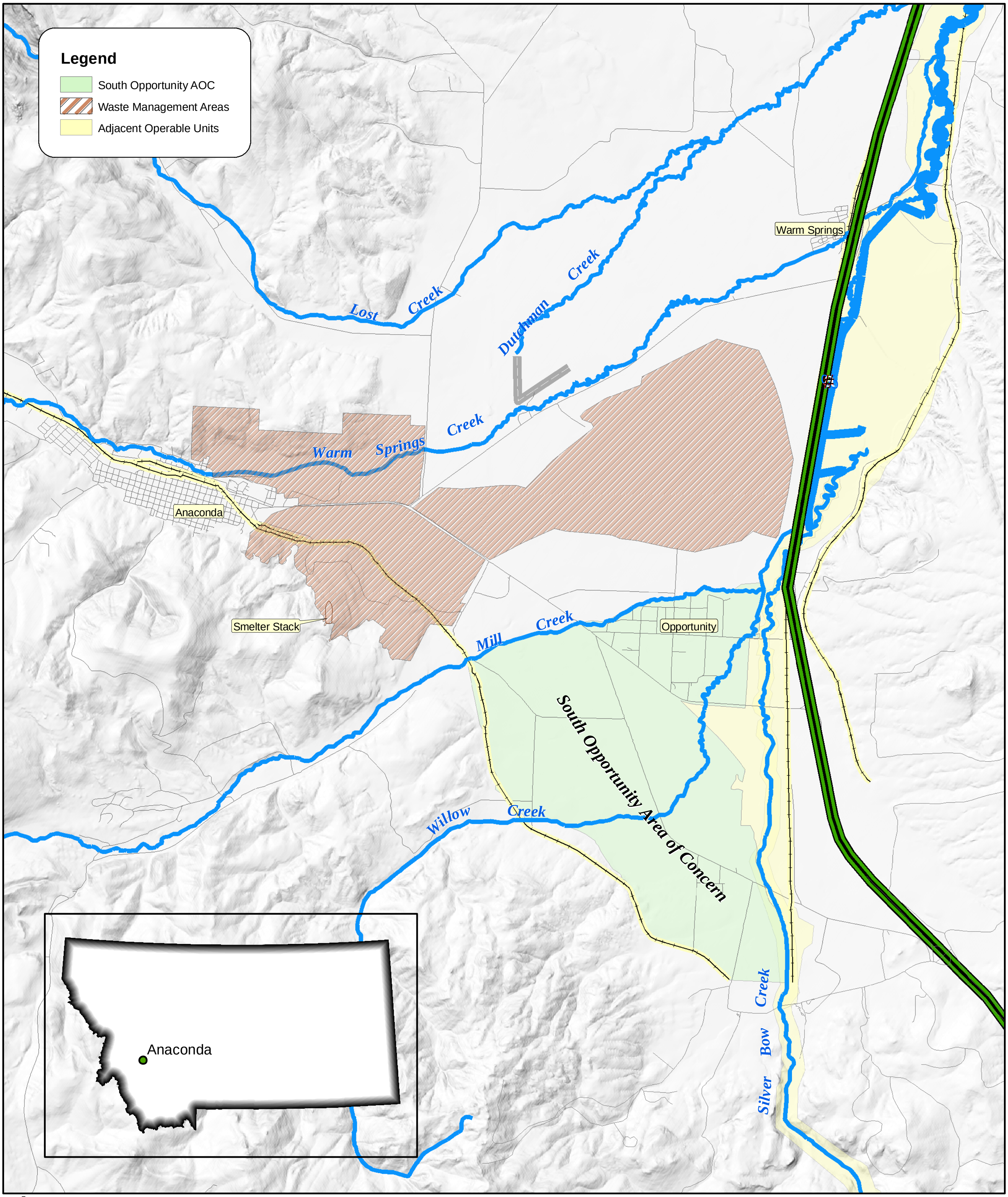

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Figure 1-1
Vicinity Map

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water, Waste, and Soils OU
Anaconda Smelter NPL Site, Montana

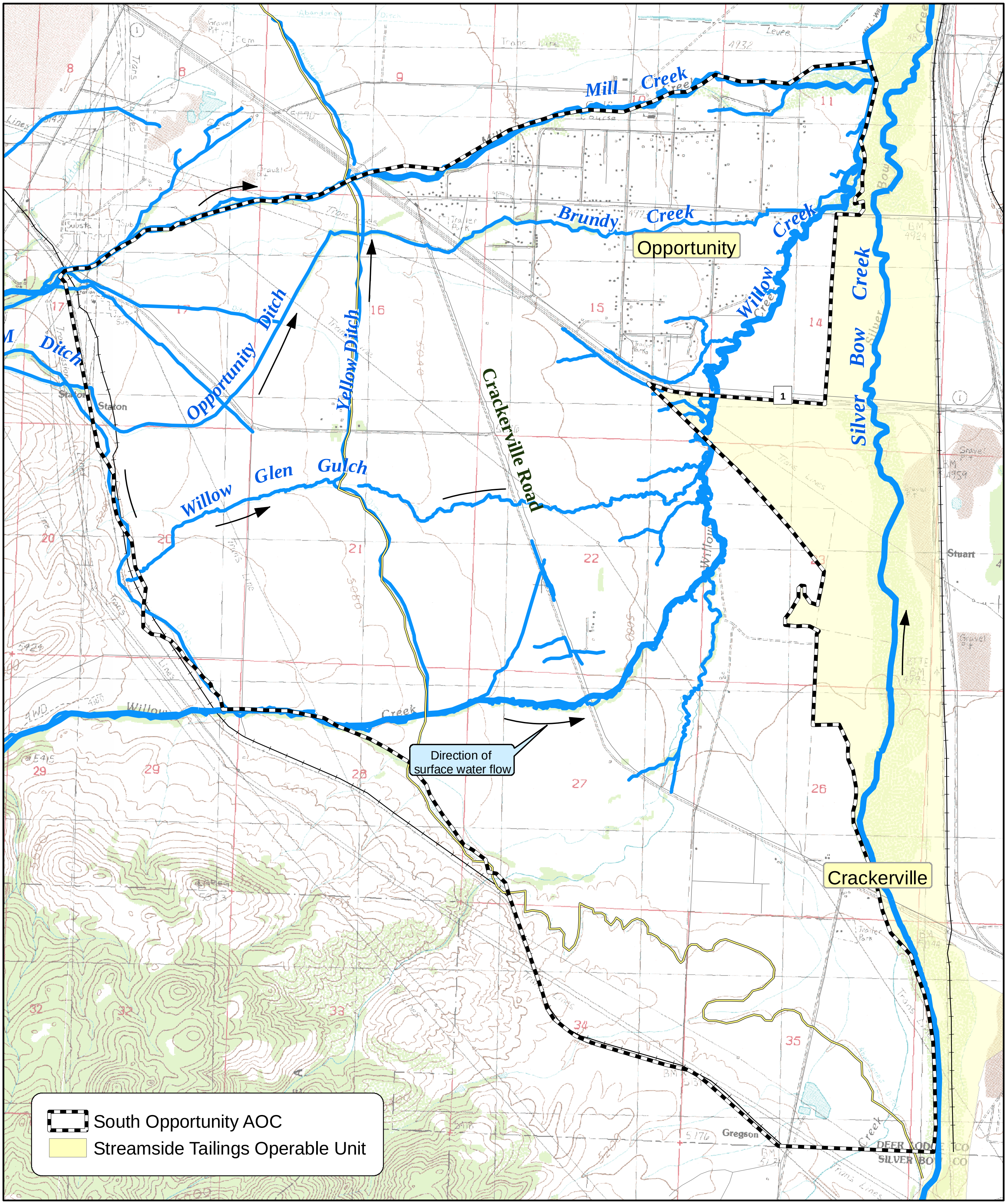

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Figure 1-2
Site Map

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

Montana Department of Environmental Quality

United States Environmental Protection Agency

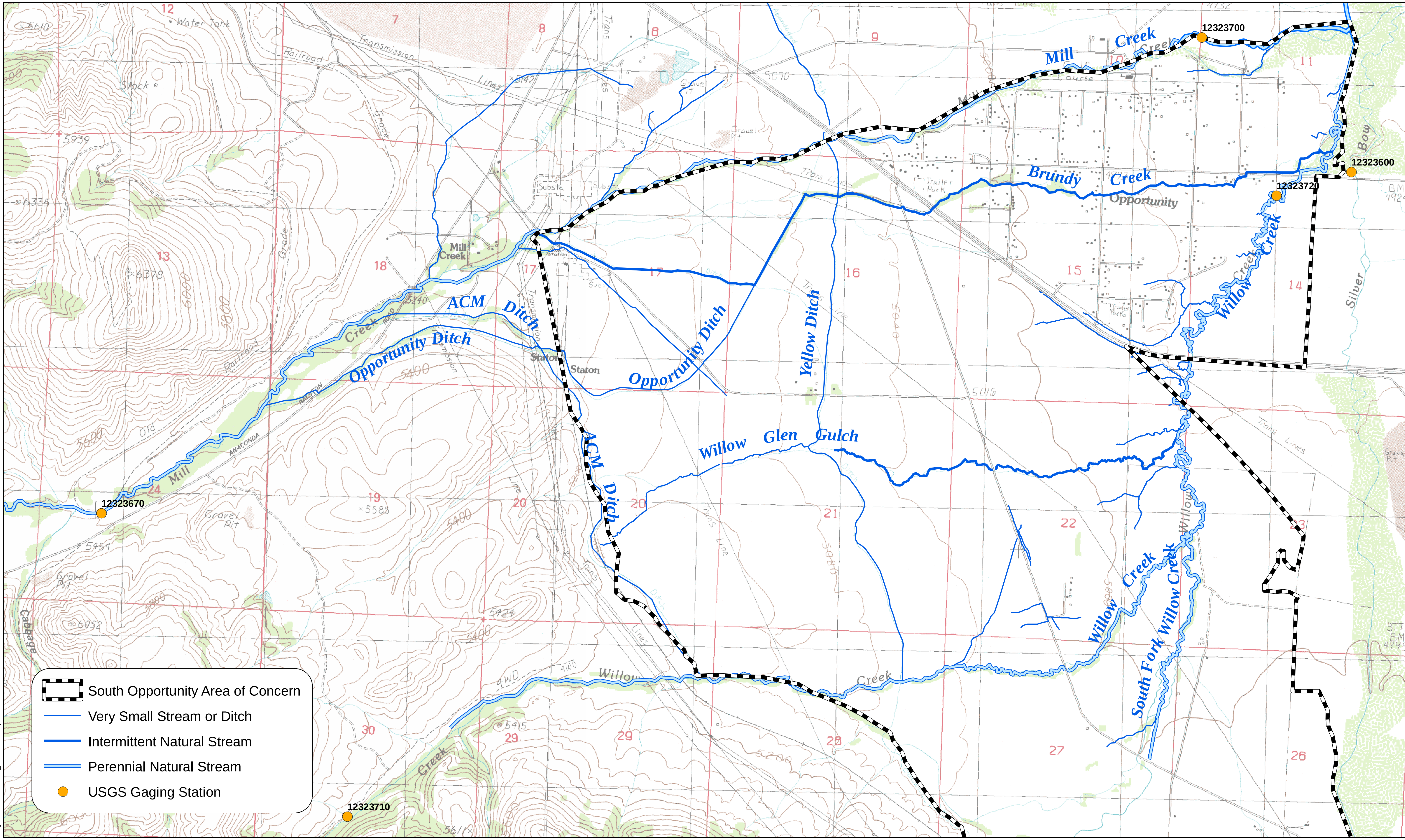

Figure 3-1
Hydrologic Features

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

0 0.5 1 2 Miles

N

Montana Department of Environmental Quality

United States Environmental Protection Agency

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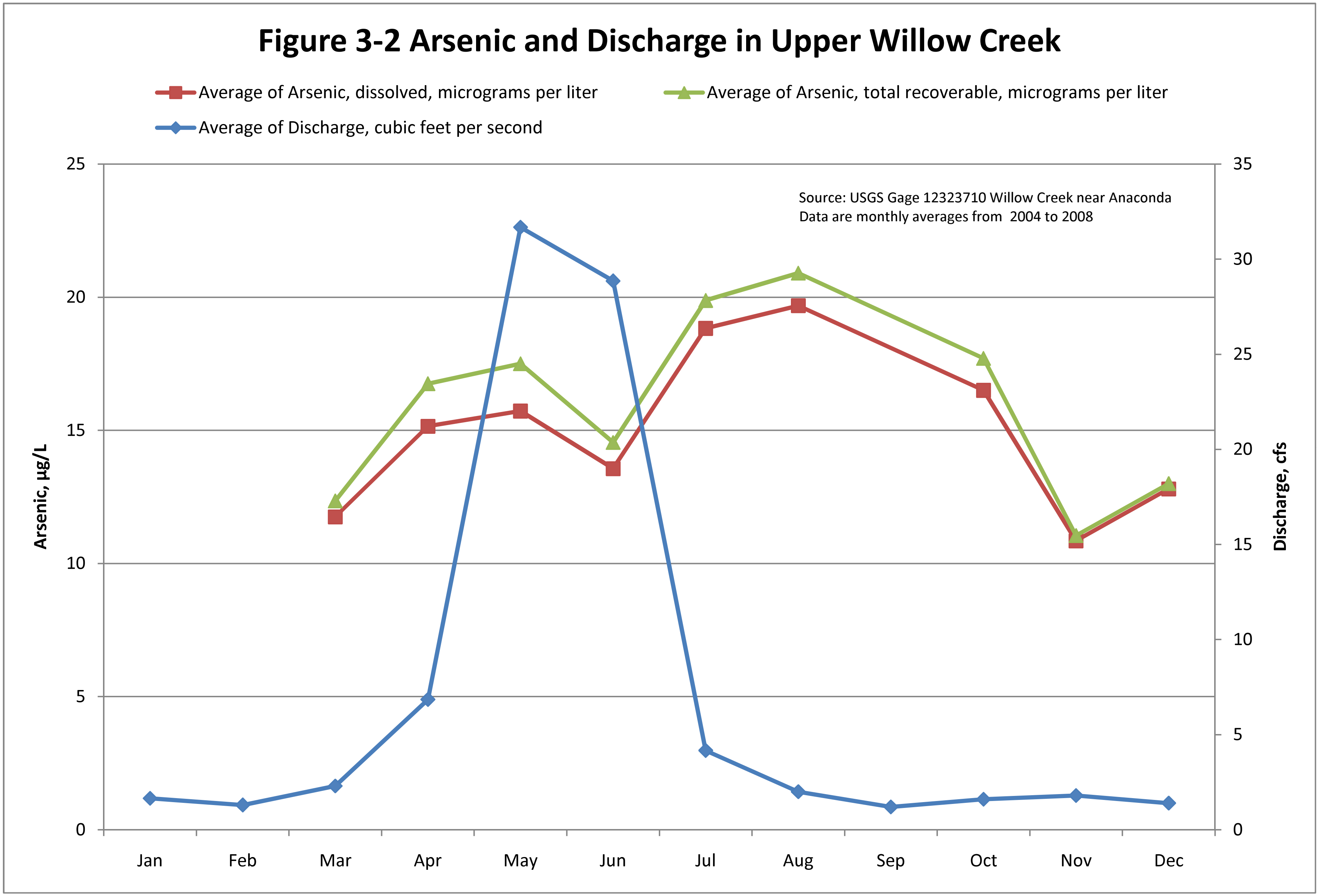

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water Waste and Soils OU
Anaconda Smelter NPL Site, Montana

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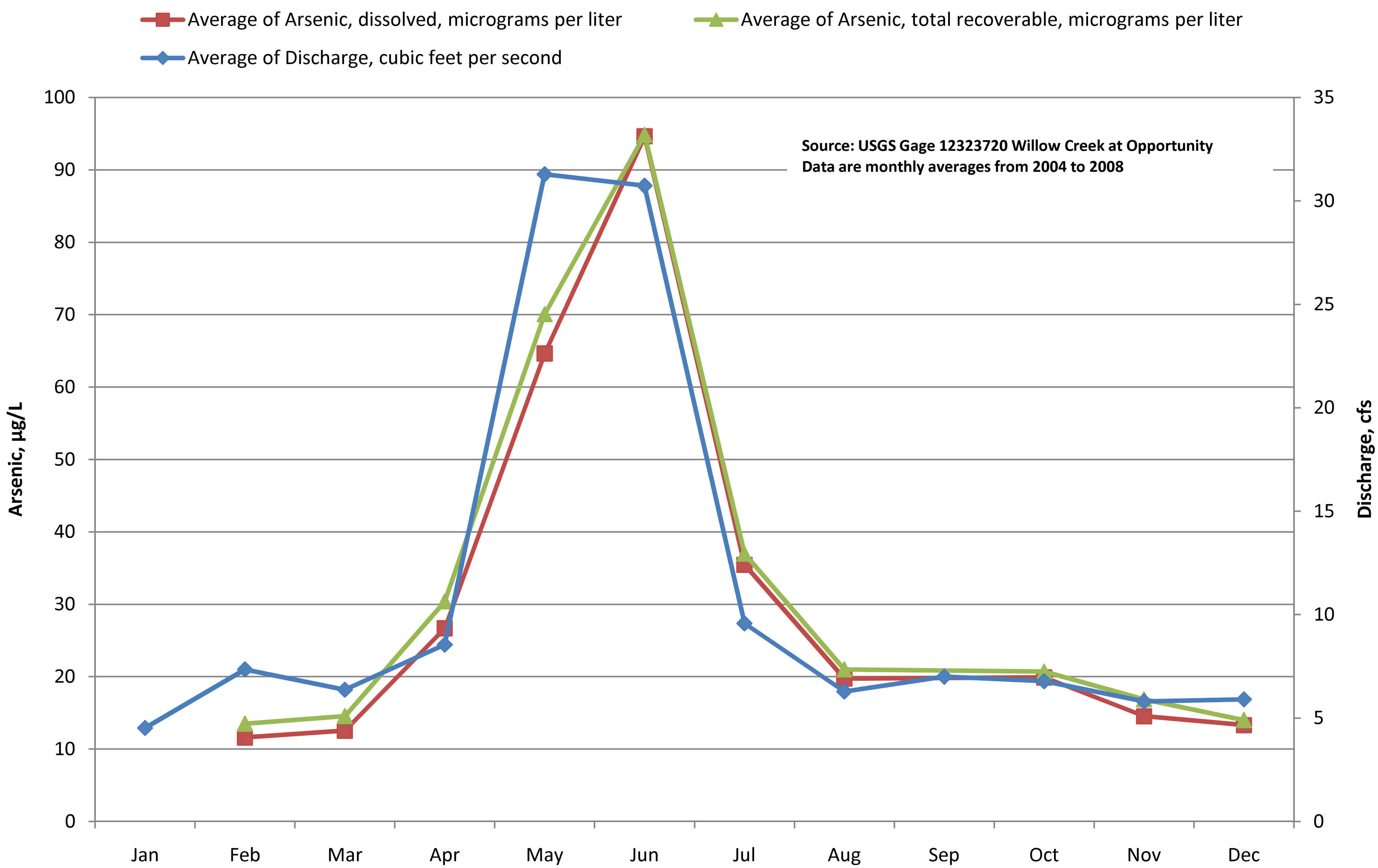
Figure 3-3 Arsenic and Discharge in Lower Willow Creek



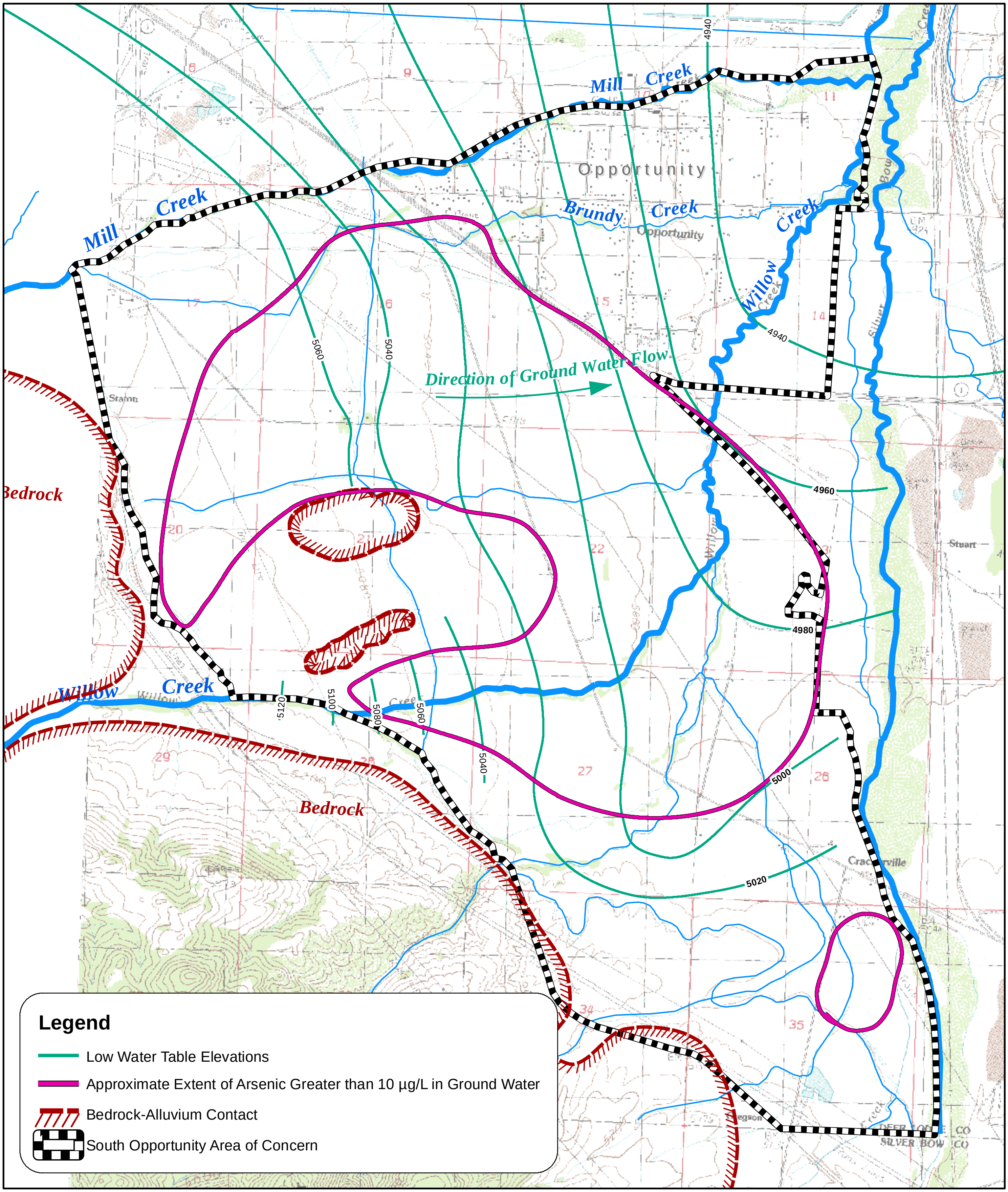


Figure 3-4
Extent of Ground Water Contamination

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

Montana Department of Environmental Quality

United States Environmental Protection Agency

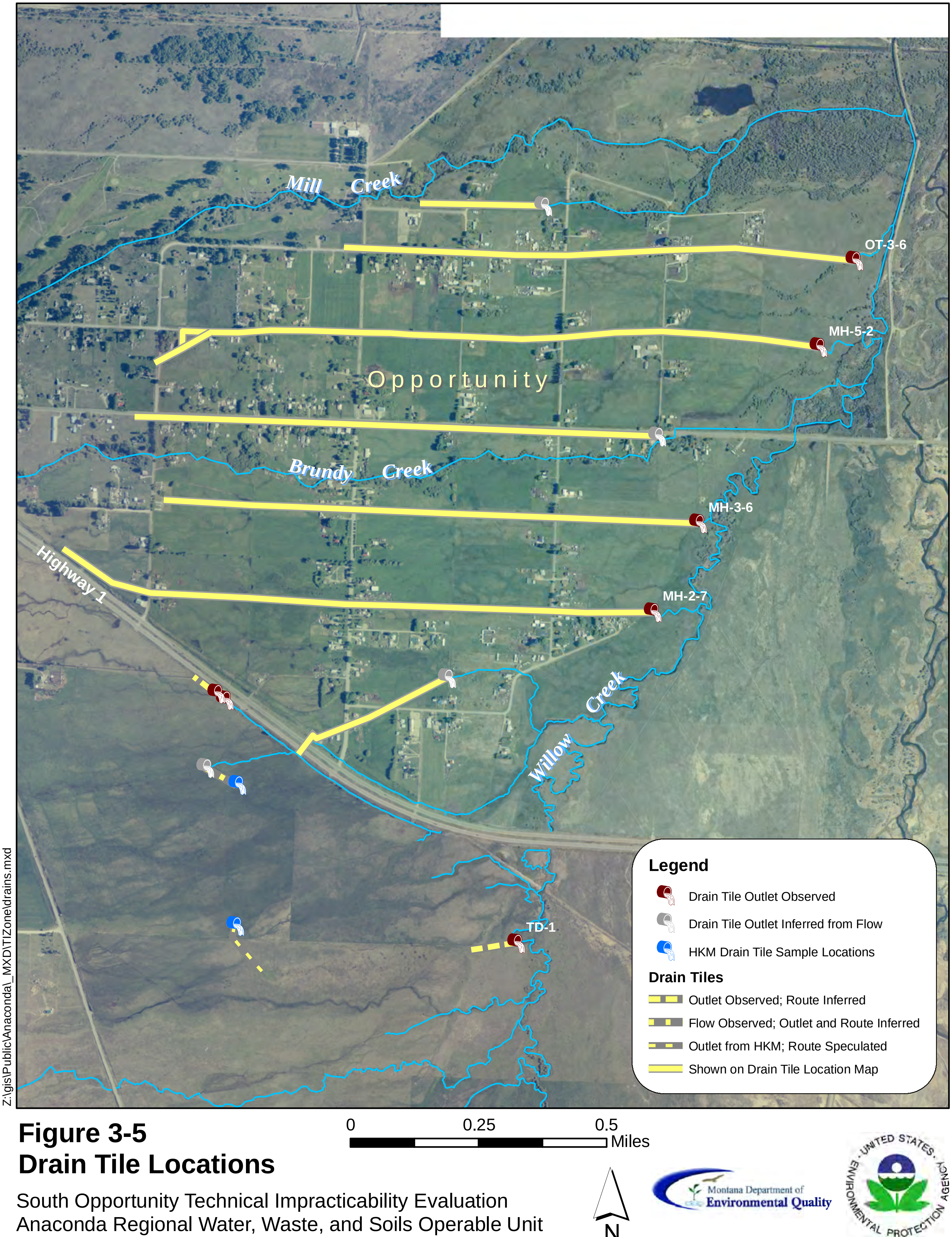


Figure 3-5
Drain Tile Locations

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water, Waste, and Soils Operable Unit
Anaconda Smelter NPL Site, Montana

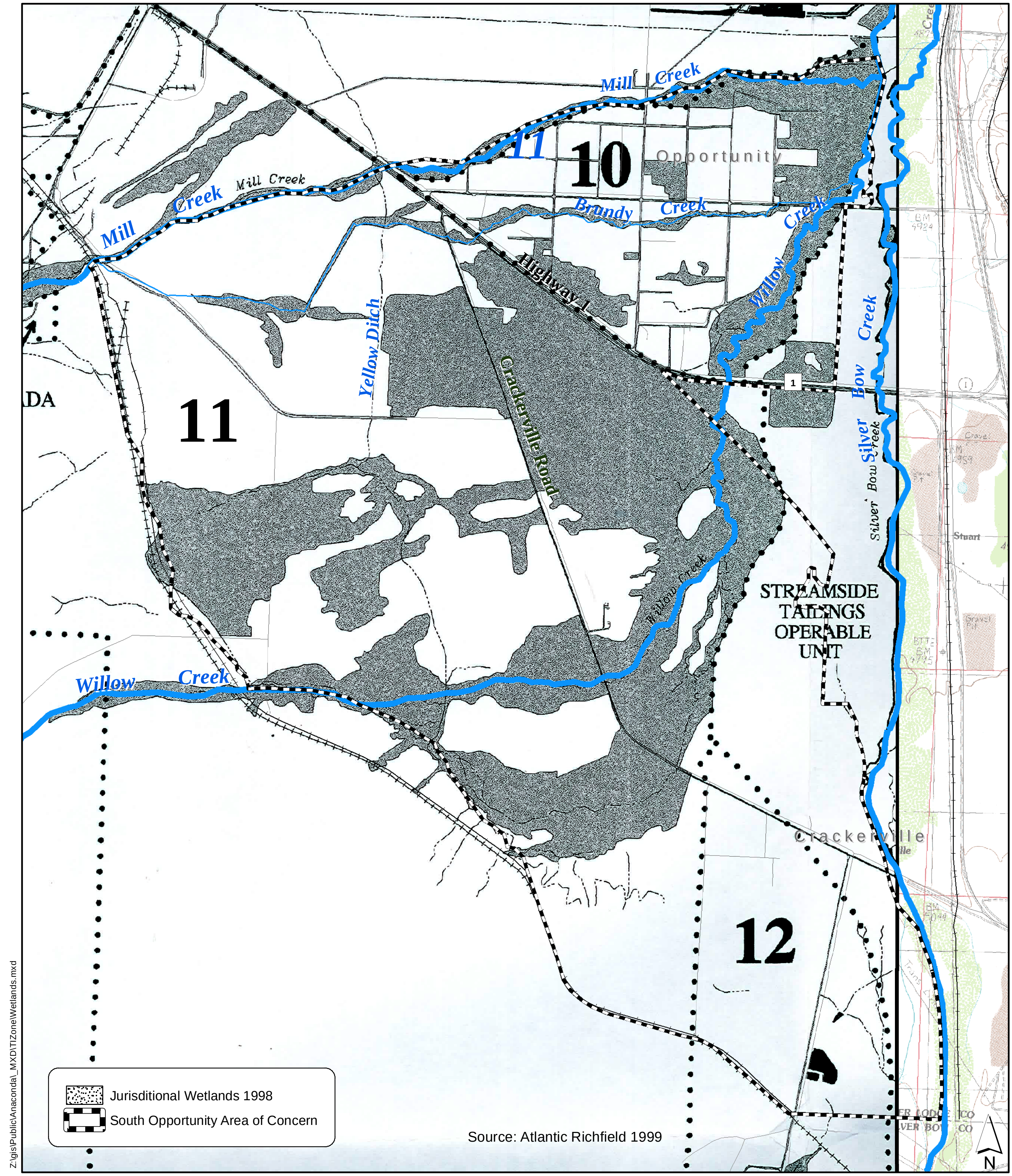


Figure 3-6
Jurisdictional Wetlands 1998
South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

Montana Department of Environmental Quality

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

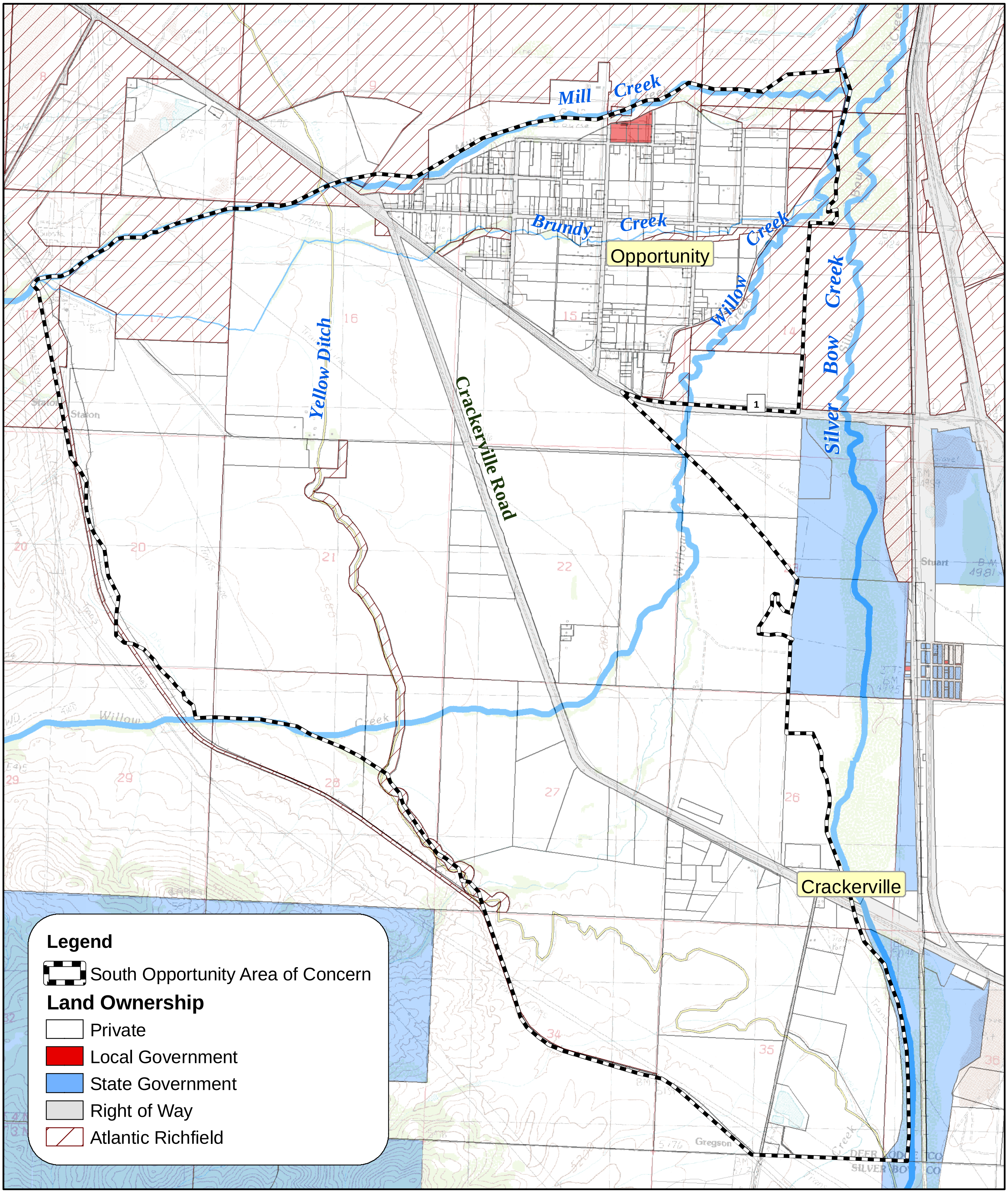


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Figure 3-7
Land Ownership

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

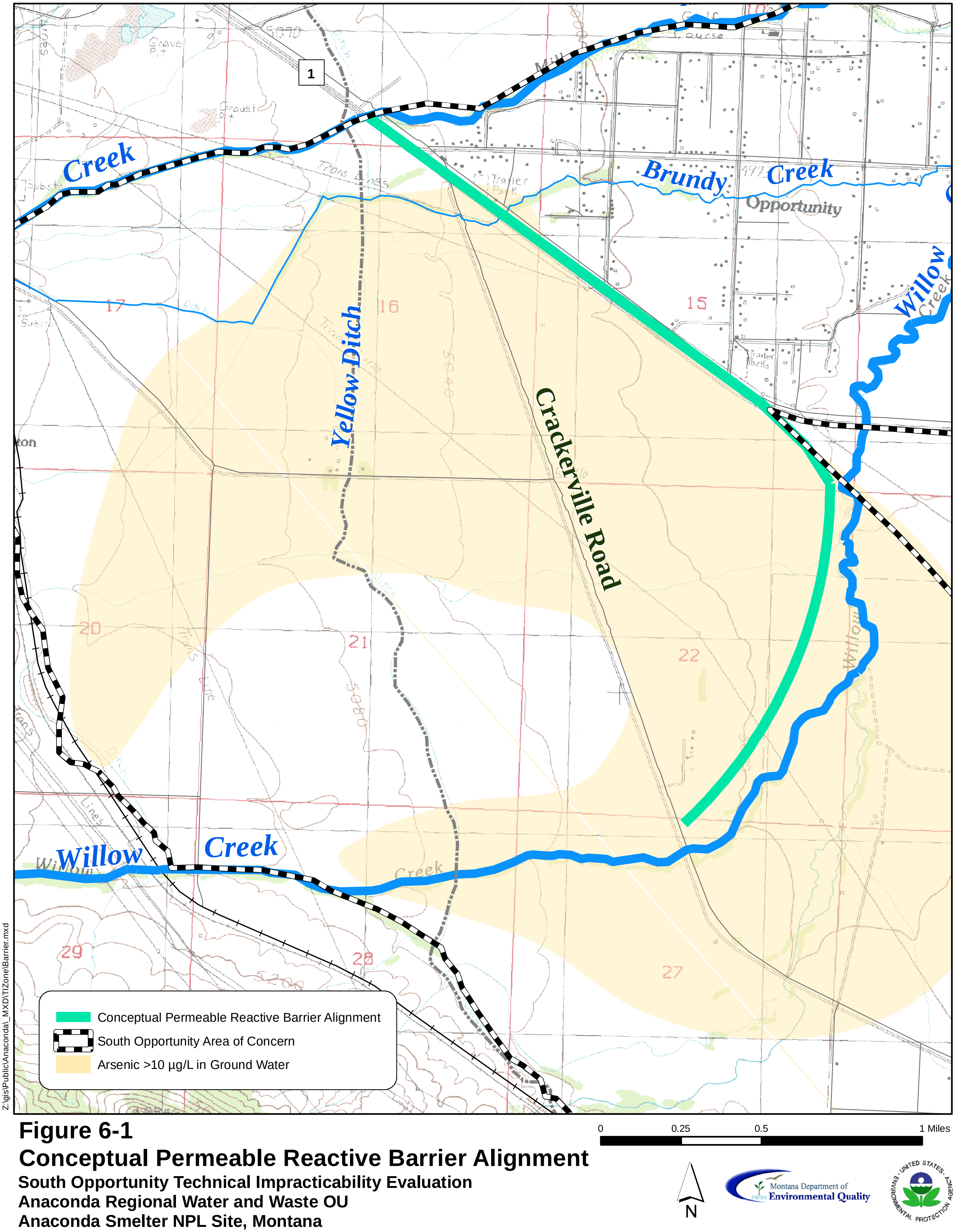
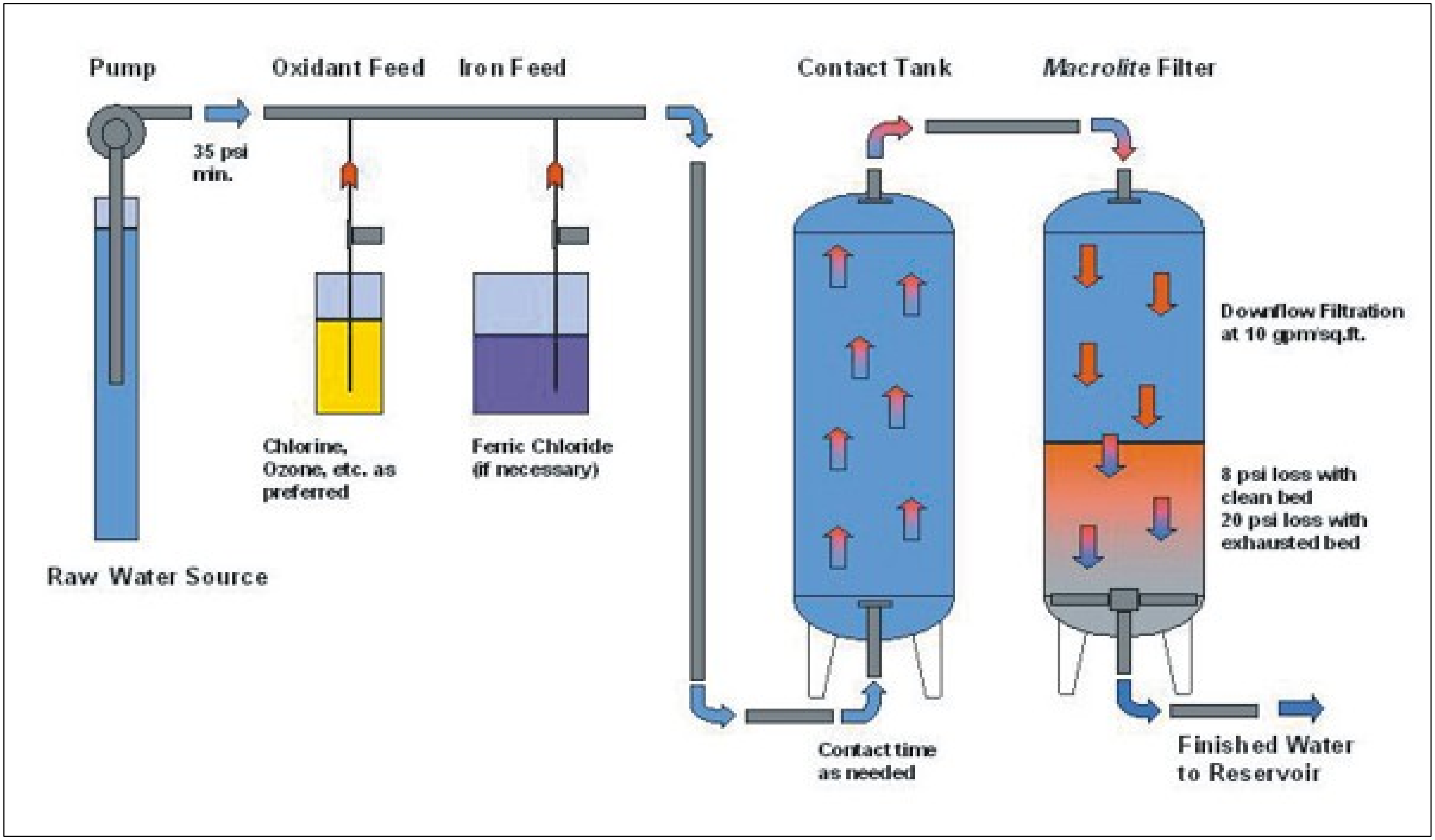


Figure 6-1
Conceptual Permeable Reactive Barrier Alignment
South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

Figure 6-2. Example Arsenic Treatment Process Flow Diagram for High Flow Rates



Schematic from French 2005

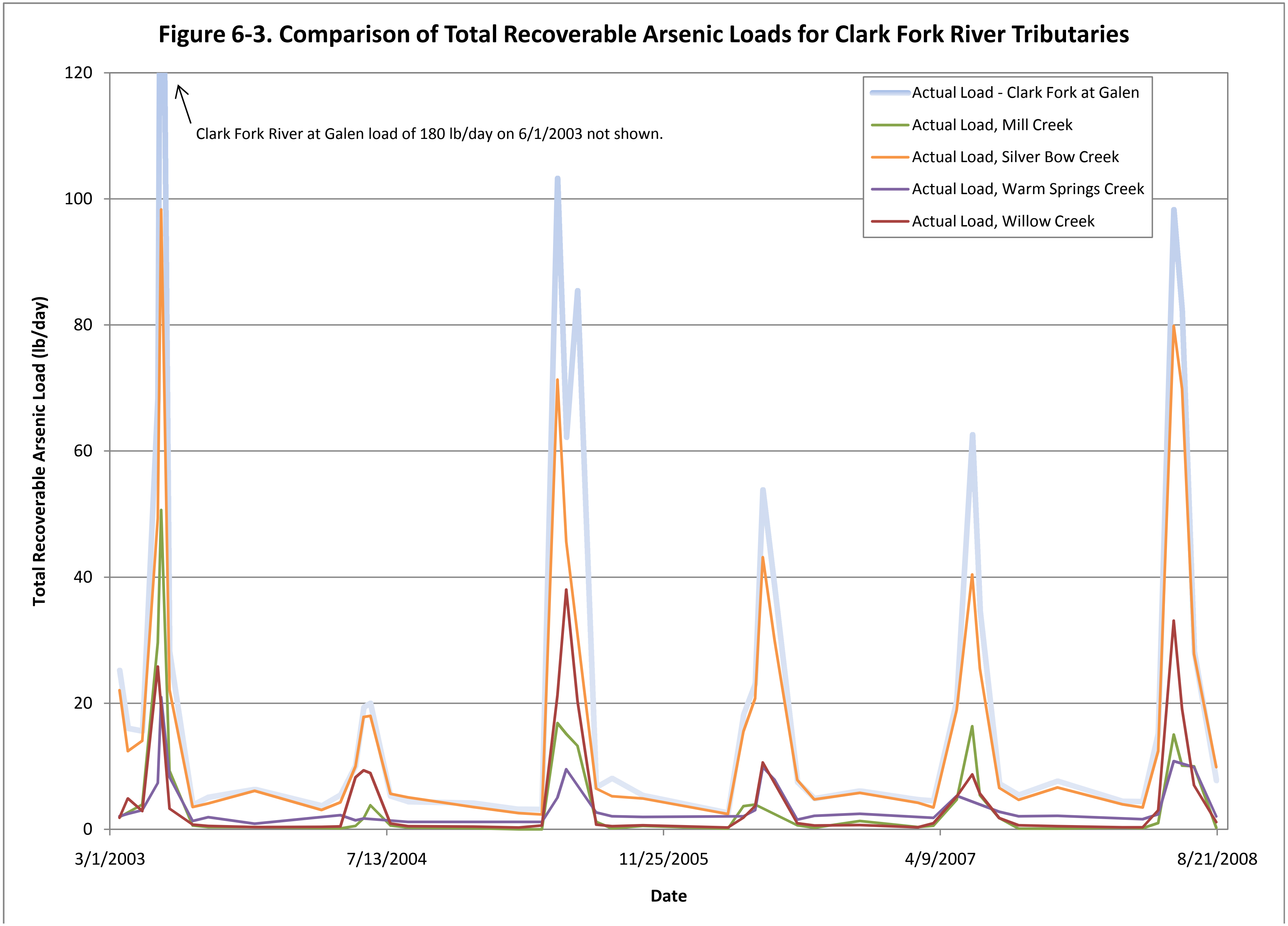
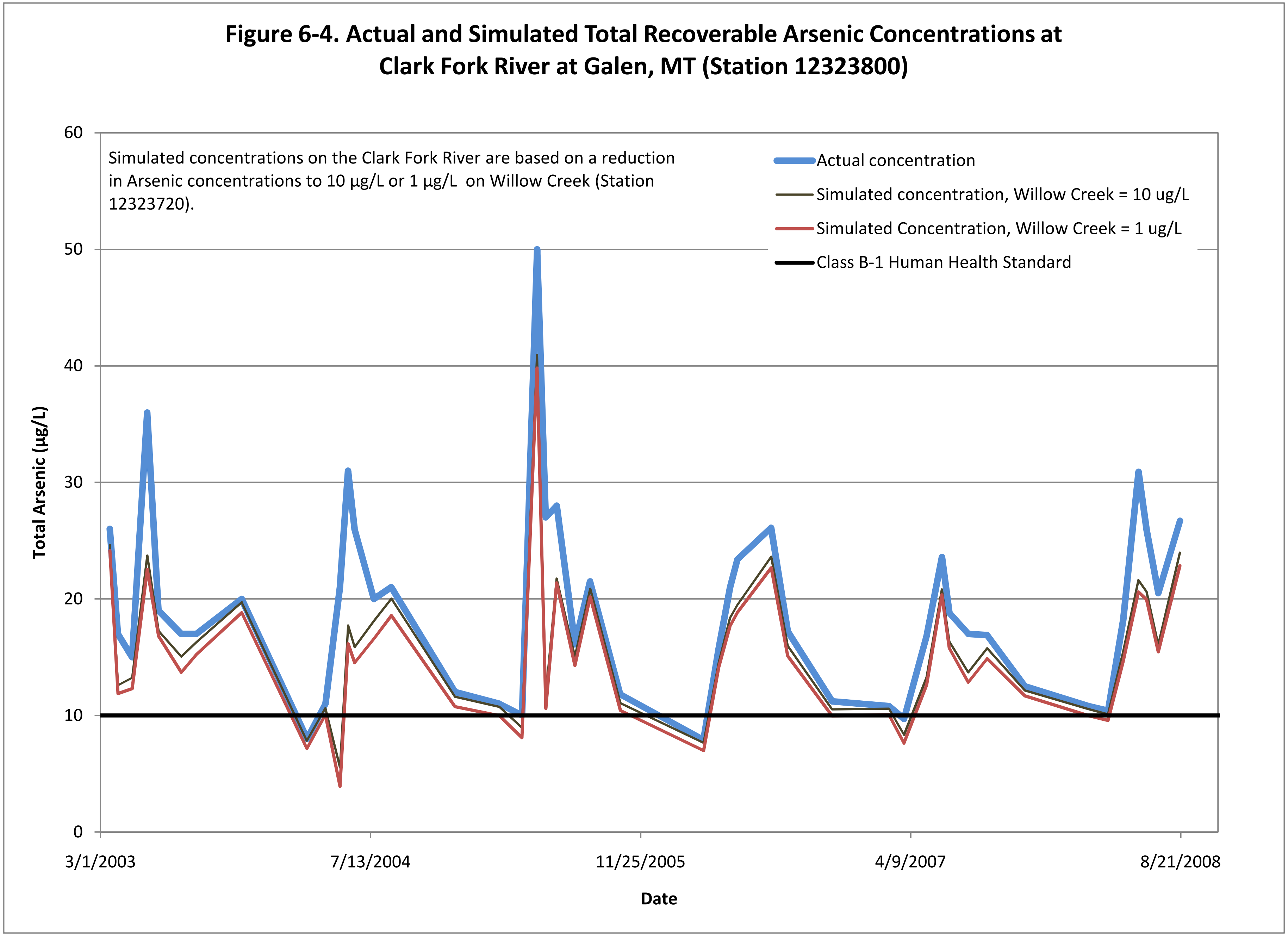
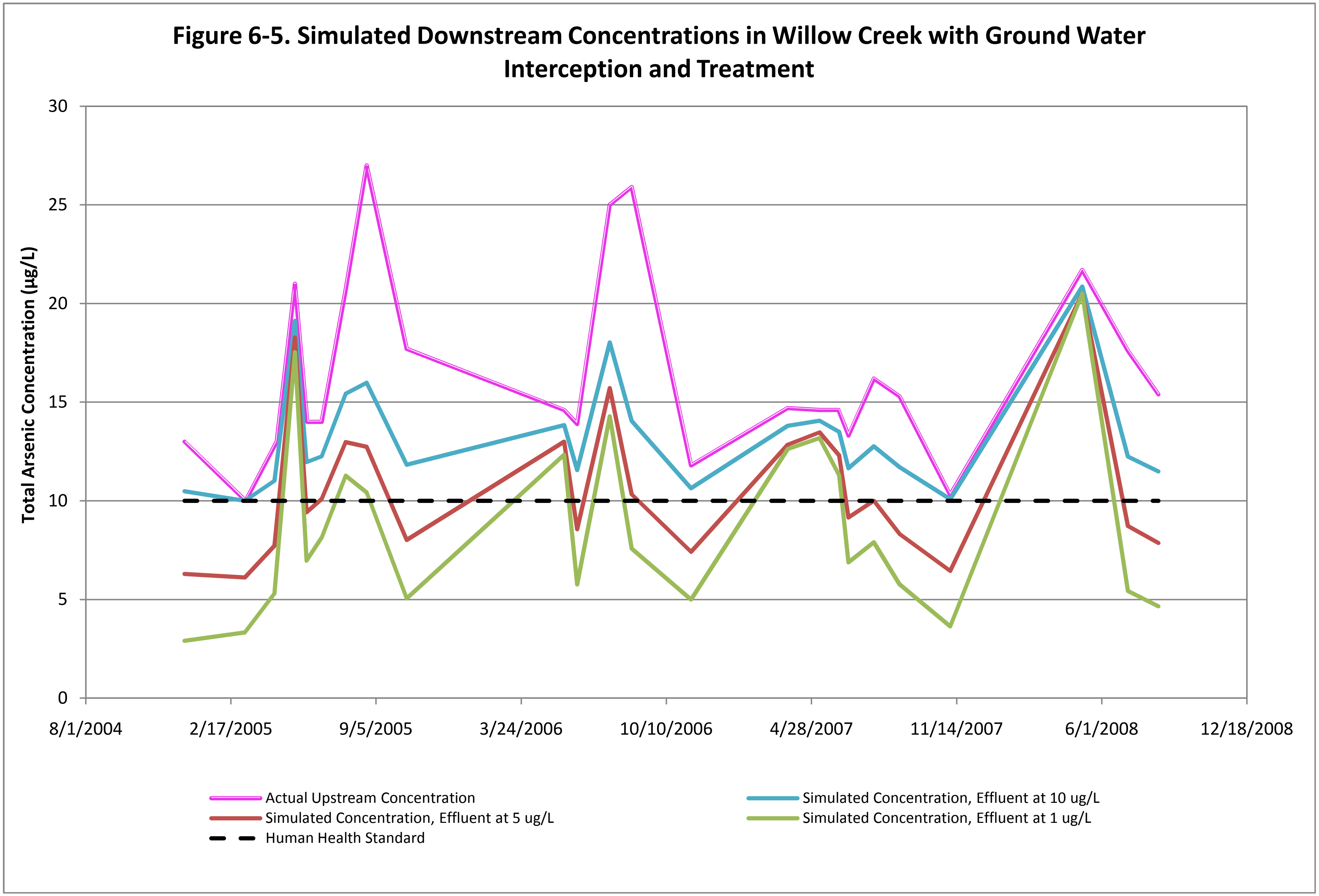


Figure 6-3. Comparison of Total Recoverable Arsenic Loads for Clark Fork River Tributaries
Total Recoverable Arsenic Load (lb/day)
120
100
80
60
40
20
0
Clark Fork River at Galen load of 180 lb/day on 6/1/2003 not shown.
Actual Load - Clark Fork at Galen
Actual Load, Mill Creek
Actual Load, Silver Bow Creek
Actual Load, Warm Springs Creek
Actual Load, Willow Creek
3/1/2003
7/13/2004
11/25/2005
4/9/2007
8/21/2008
Date



actualvssimulated-willow.xlsx Total Conc



willowcreekpivot.xls treatment simulation

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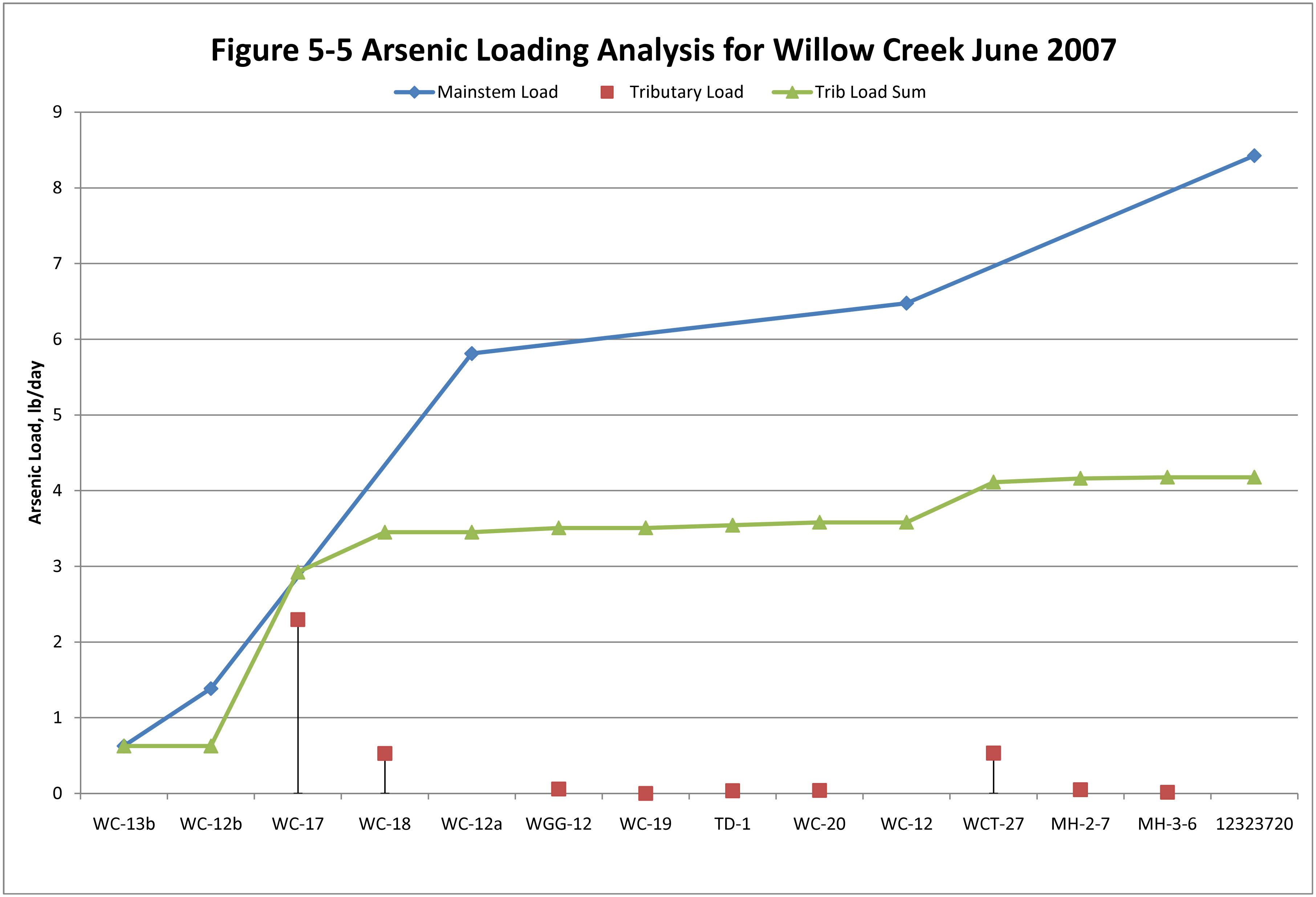

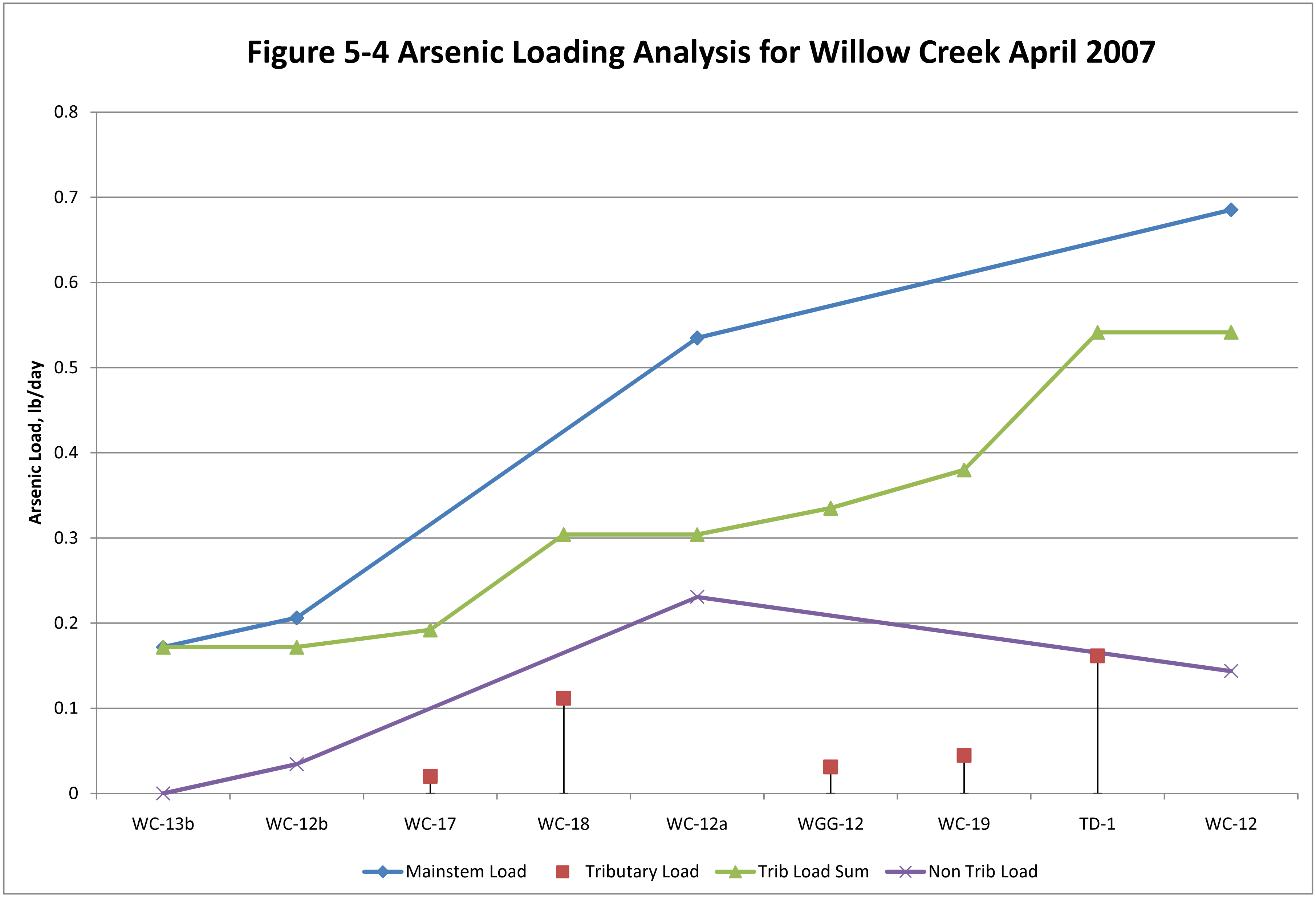
Figure 5-4 Arsenic Loading Analysis for Willow Creek April 2007
Arsenic Load, lb/day
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
WC-13b
WC-12b
WC-17
WC-18
WC-12a
WGG-12
WC-19
TD-1
WC-12
Mainstem Load
Tributary Load
Trib Load Sum
Non Trib Load

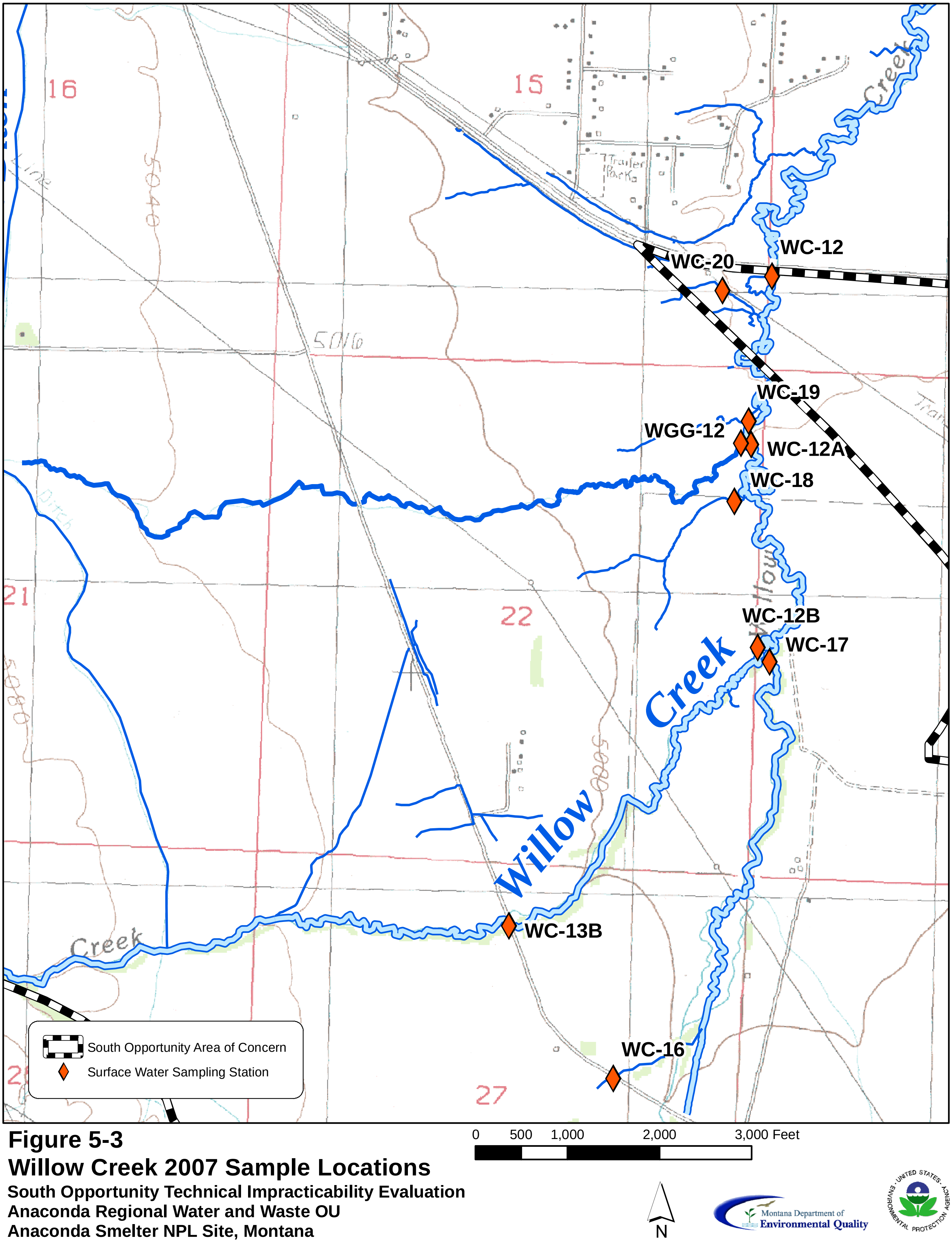

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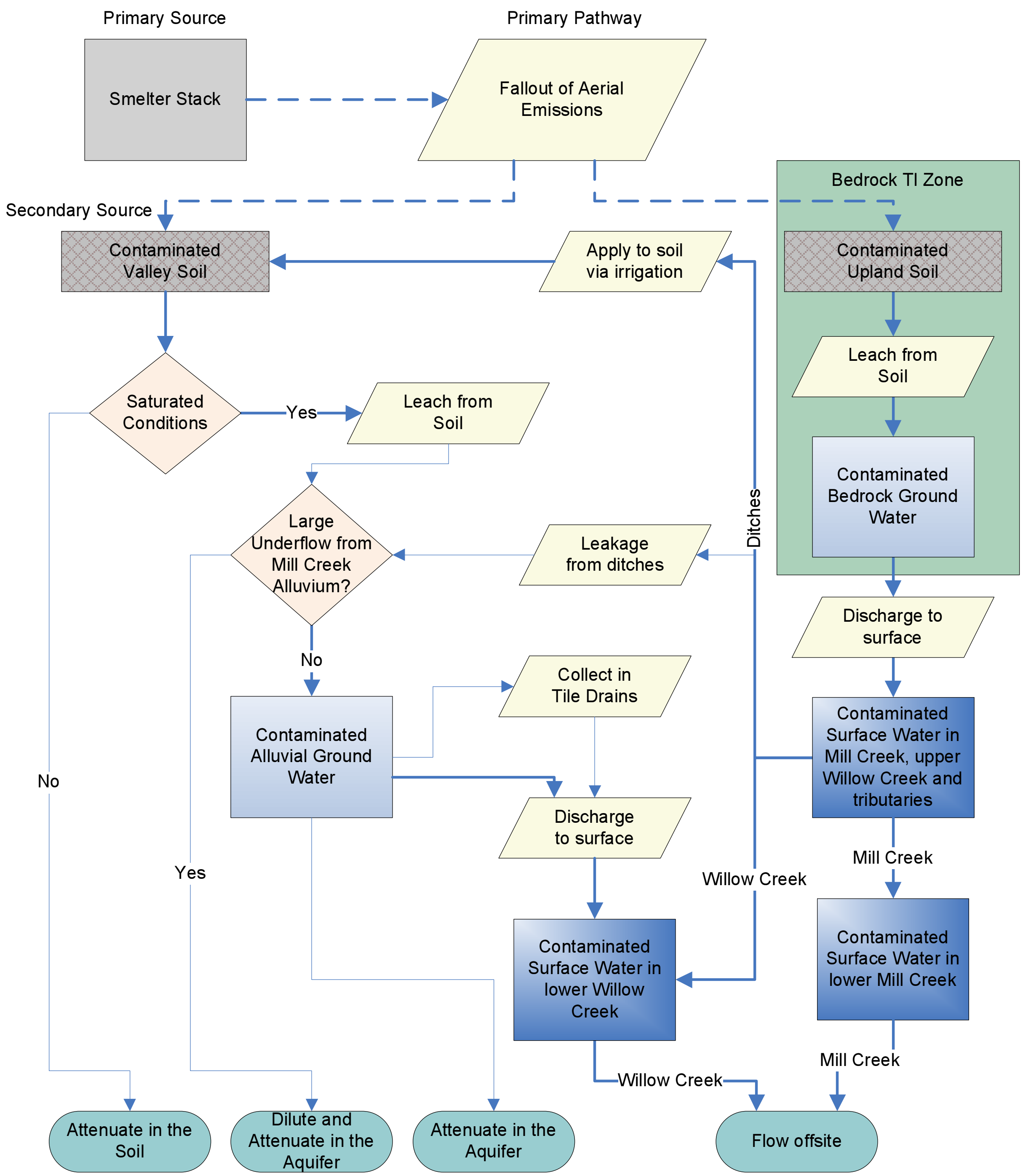
Figure 5-3
Willow Creek 2007 Sample Locations
South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana



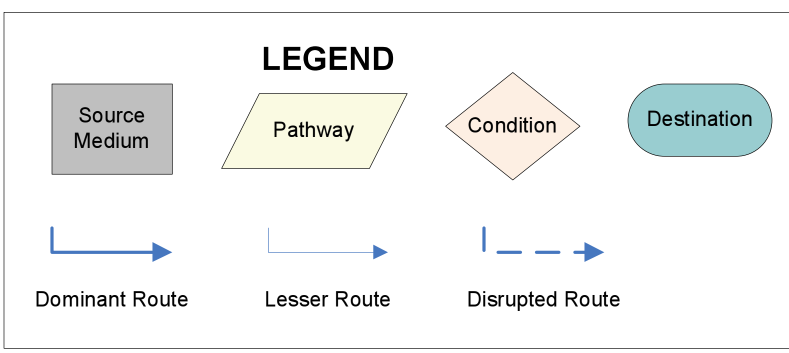
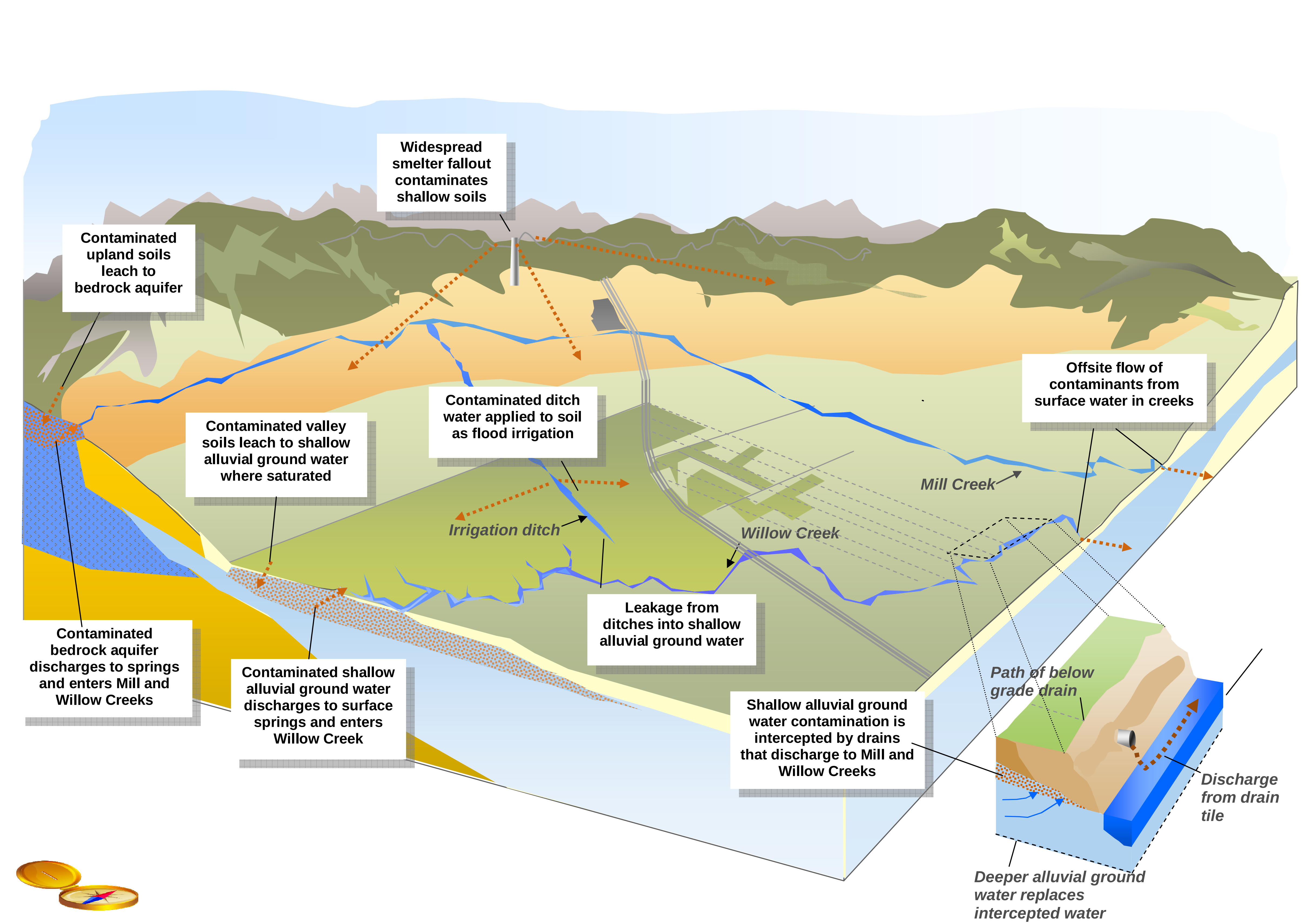


Figure 5-2
CSM Flow Chart

South Opportunity Technical Impracticability Evaluation
Anaconda Smelter NPL Site, Anaconda, Montana



Legend

- Contaminated ground water
- Uncontaminated shallow ground water
- Uncontaminated bedrock ground water
- Flood irrigated land
- Buried drains
- Highway 1

Figure not to scale

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Montana Department of Environmental Quality

Figure 5-1

Conceptual Site Model
South Opportunity
Technical Impracticability
Evaluation

ANACONDA SMELTER NPL SITE
ANACONDA, MONTANA

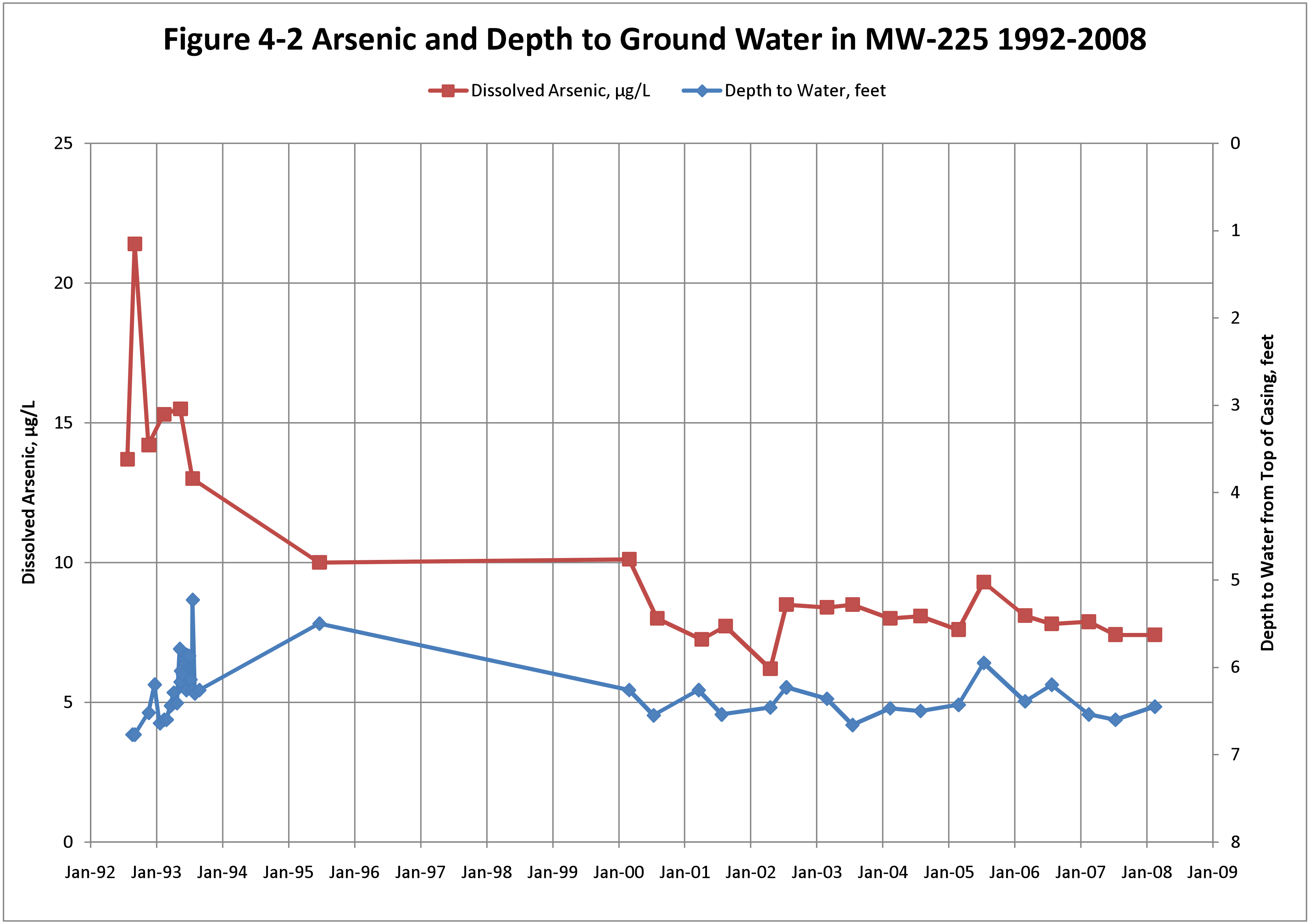


Figure 4-2 Arsenic and Depth to Ground Water in MW-225 1992-2008
Dissolved Arsenic, µg/L
Depth to Water, feet
Dissolved Arsenic, µg/L
Depth to Water from Top of Casing, feet
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
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Jan-01
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Jan-07
Jan-08
Jan-09

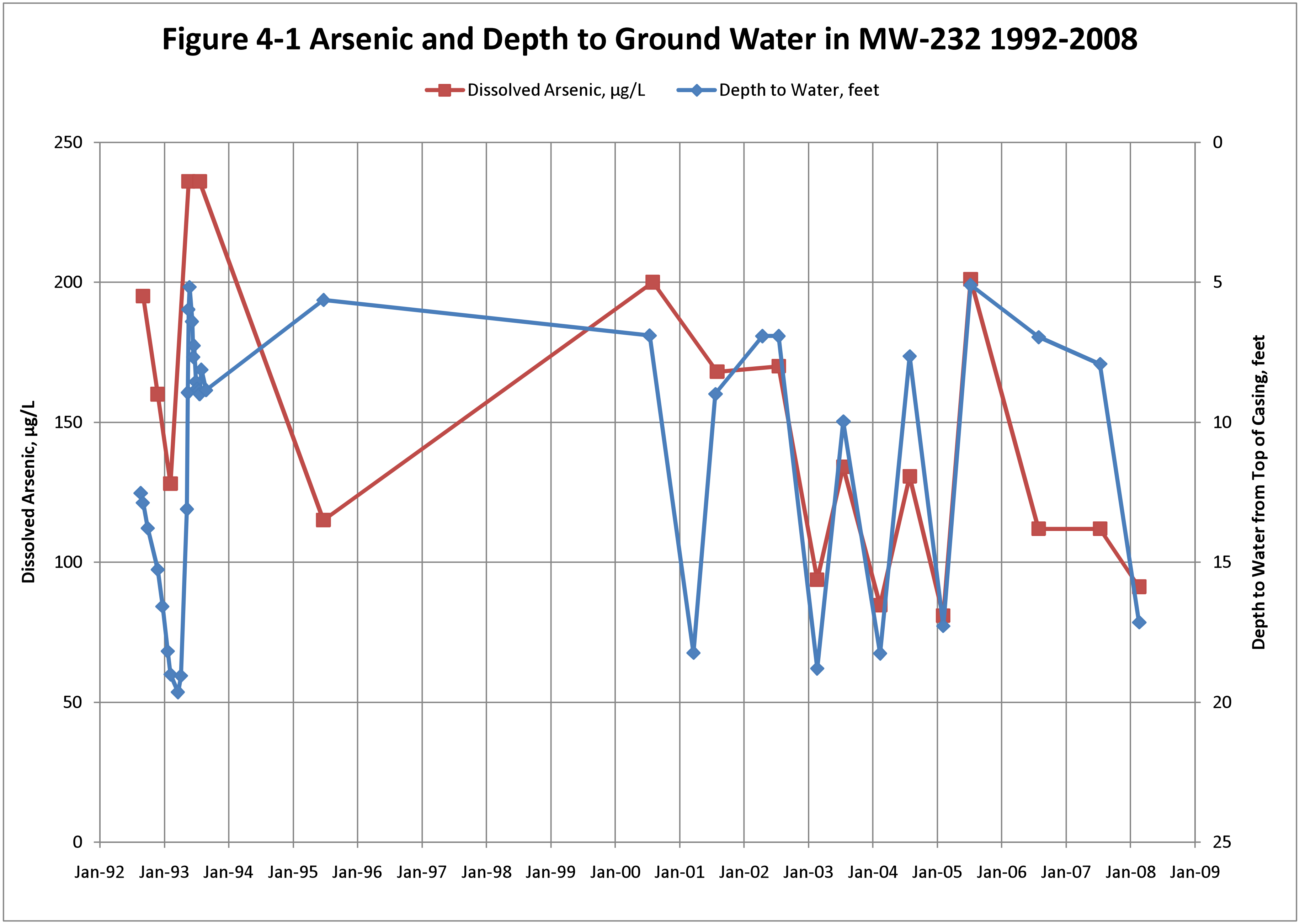


Figure 4-1 Arsenic and Depth to Ground Water in MW-232 1992-2008
Dissolved Arsenic, µg/L
Depth to Water, feet
250
200
150
100
50
0
Dissolved Arsenic, µg/L
0
5
10
15
20
25
Depth to Water from Top of Casing, feet
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

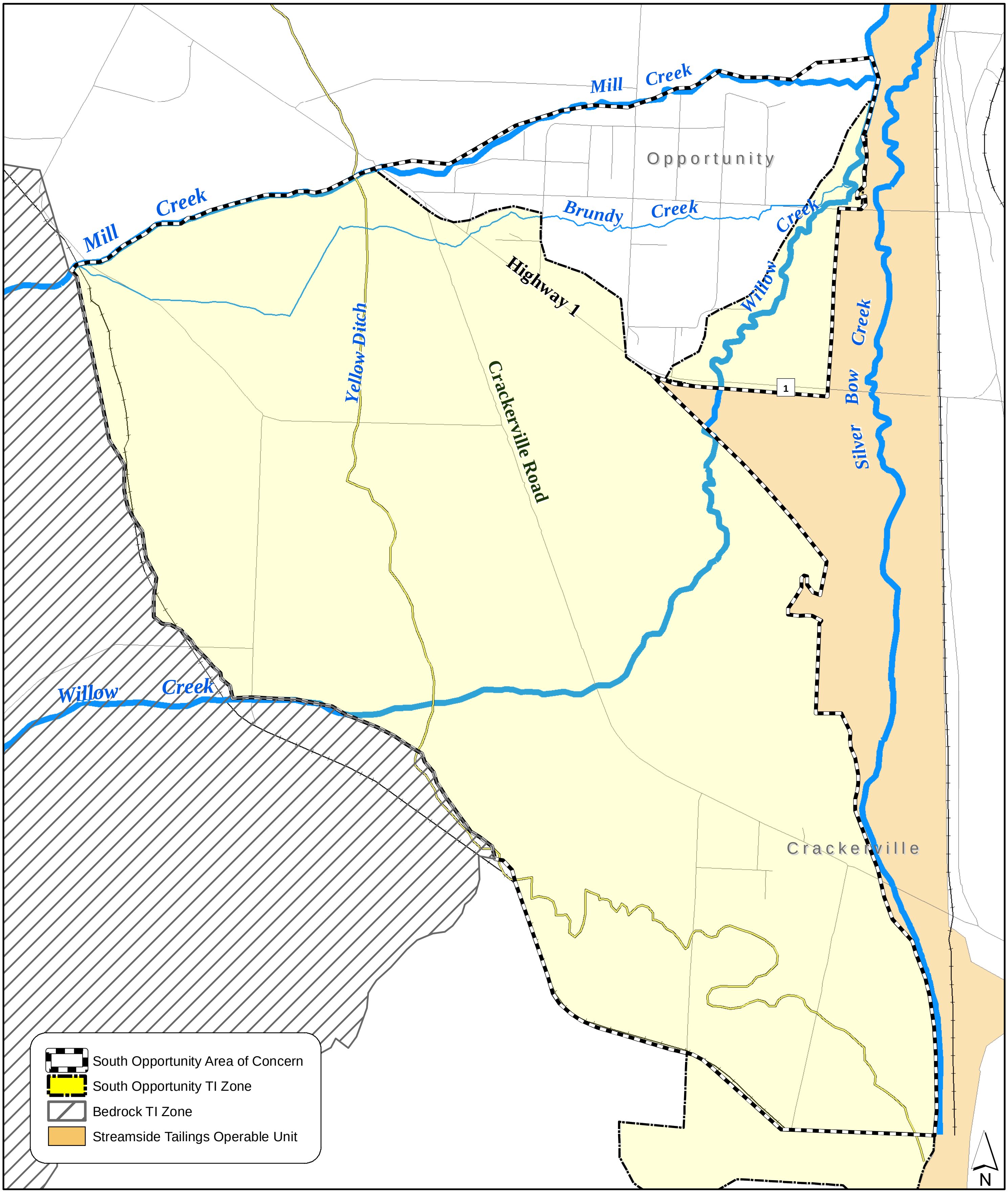


Figure 8-1
South Opportunity Technical Impracticability Zone

South Opportunity Technical Impracticability Evaluation
Anaconda Regional Water and Waste OU
Anaconda Smelter NPL Site, Montana

Tables

TABLE 6-1a. Contaminated Soil Removal and Disposal

SCREENING COST ESTIMATE SUMMARY

Contaminated Soil Removal and Disposal

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes cremoval of arsenic-contaminated soil, disposal of the contaminated soil at the Opportunity ponds waste management area (WMA) and related O&M of the consoldiated wastes, development of a borrow source and backfilling the excavation with clean soil, and inspections and activities related to 5 year site reviews.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Contaminant Source Removal, Transport, and Consolidation at the Opportunity Ponds WMA	4,053,500	BCY	$10.00	$40,535,000.00	Refer to Table 6-1c for unit quantity
Borrow Area Development, Hauling, and Placement	4,539,920	LCY	$15.00	$68,098,800.00	Refer to Table 6-1c for unit quantity
Seed Bed Preparation and Fertilization	3,715	AC	$1,000.00	$3,715,000.00	Refer to Table 6-1c for unit quantity
Organic Matter Addition	3,215	AC	$750.00	$2,411,250.00	Refer to Table 6-1c for unit quantity
SUBTOTAL				**$114,760,050.00**	
Contingency (Scope and Bid)	25%			$28,690,013	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$143,450,063	
Project Management	5%			$7,172,503	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$8,607,004	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$8,607,004	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$21,517,509	Middle value of the recommended range was used.
TOTAL				$189,354,083	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$189,354,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS (Years 1 through 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Seed Bed Preparation and Fertilization	25	AC	$1,000.00	$25,000.00	Refer to Table 6-1c for unit quantity
SUBTOTAL				**$25,000**	
Contingency (Scope and Bid)	25%			$6,250	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$31,250	
Project Management	10%			$3,125	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$4,688	Middle value of the recommended range was used.
TOTAL				$39,063	
ESTIMATED ANNUAL O&M COST FOR MAJOR REMEDY COMPONENTS				**$39,000**	Estimated annual O&M cost rounded to nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				**$50,000**	
Contingency (Scope and Bid)	25%			$12,500	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$62,500	
Project Management	10%			$6,250	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,375	Middle value of recommended range was used.
TOTAL				$78,125	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$78,000**	Estimated periodic cost rounded to nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.

Percentages for contingency and professional/technical services based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

AC	Acre	QTY	Quantity
BCY	Bank Cubic Yard	YR	Year
LCY	Loose Cubic Yard	LS	Lump Sum

TABLE 6-1b. Contaminated Soil Removal and Disposal

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$189,354,000	$0	$0	$189,354,000	1.0000	$189,354,000
1	$0	$39,000	$0	$39,000	0.9346	$36,449
2	$0	$39,000	$0	$39,000	0.8734	$34,063
3	$0	$39,000	$0	$39,000	0.8163	$31,836
4	$0	$39,000	$0	$39,000	0.7629	$29,753
5	$0	$39,000	$78,000	$117,000	0.7130	$83,421
6	$0	$39,000	$0	$39,000	0.6663	$25,986
7	$0	$39,000	$0	$39,000	0.6227	$24,285
8	$0	$39,000	$0	$39,000	0.5820	$22,698
9	$0	$39,000	$0	$39,000	0.5439	$21,212
10	$0	$39,000	$78,000	$117,000	0.5083	$59,471
11	$0	$39,000	$0	$39,000	0.4751	$18,529
12	$0	$39,000	$0	$39,000	0.4440	$17,316
13	$0	$39,000	$0	$39,000	0.4150	$16,185
14	$0	$39,000	$0	$39,000	0.3878	$15,124
15	$0	$39,000	$78,000	$117,000	0.3624	$42,401
16	$0	$39,000	$0	$39,000	0.3387	$13,209
17	$0	$39,000	$0	$39,000	0.3166	$12,347
18	$0	$39,000	$0	$39,000	0.2959	$11,540
19	$0	$39,000	$0	$39,000	0.2765	$10,784
20	$0	$39,000	$78,000	$117,000	0.2584	$30,233
21	$0	$39,000	$0	$39,000	0.2415	$9,419
22	$0	$39,000	$0	$39,000	0.2257	$8,802
23	$0	$39,000	$0	$39,000	0.2109	$8,225
24	$0	$39,000	$0	$39,000	0.1971	$7,687
25	$0	$39,000	$78,000	$117,000	0.1842	$21,551
26	$0	$39,000	$0	$39,000	0.1722	$6,716
27	$0	$39,000	$0	$39,000	0.1609	$6,275
28	$0	$39,000	$0	$39,000	0.1504	$5,866
29	$0	$39,000	$0	$39,000	0.1406	$5,483
30	$0	$39,000	$78,000	$117,000	0.1314	$15,374
31	$0	$39,000	$0	$39,000	0.1228	$4,789
32	$0	$39,000	$0	$39,000	0.1147	$4,473
33	$0	$39,000	$0	$39,000	0.1072	$4,181
34	$0	$39,000	$0	$39,000	0.1002	$3,908
35	$0	$39,000	$78,000	$117,000	0.0937	$10,963
36	$0	$39,000	$0	$39,000	0.0875	$3,413
37	$0	$39,000	$0	$39,000	0.0818	$3,190
38	$0	$39,000	$0	$39,000	0.0765	$2,984
39	$0	$39,000	$0	$39,000	0.0715	$2,789
40	$0	$39,000	$78,000	$117,000	0.0668	$7,816
41	$0	$39,000	$0	$39,000	0.0624	$2,434
42	$0	$39,000	$0	$39,000	0.0583	$2,274
43	$0	$39,000	$0	$39,000	0.0545	$2,126
44	$0	$39,000	$0	$39,000	0.0509	$1,985
45	$0	$39,000	$78,000	$117,000	0.0476	$5,569
46	$0	$39,000	$0	$39,000	0.0445	$1,736
47	$0	$39,000	$0	$39,000	0.0416	$1,622
48	$0	$39,000	$0	$39,000	0.0389	$1,517
49	$0	$39,000	$0	$39,000	0.0363	$1,416
50	$0	$39,000	$78,000	$117,000	0.0339	$3,966
TOTALS:	$189,354,000	$1,950,000	$780,000	**$192,084,000**		$190,079,391
TOTAL PRESENT VALUE [5]						**$190,079,000**

Notes:

[1] Duration is assumed to be 50 years for present value analysis.

[2] Capital costs, for purposes of this screening analysis, are assumed to occur in Year 1.

[3] Total annual expenditure is the total cost per year with no discounting.

[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.

[5] Total present value is rounded to the nearest $1,000.

TABLE 6-2a. In-Situ Groundwater Treatment Using a Permeable Reactive Barrier

SCREENING COST ESTIMATE SUMMARY

In Situ Groundwater Treatment Using a Permeable Reactive Barrier

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a permeable reactive barrier (PRB) capable of treating arsenic-contaminated water in situ, related repair and maintenance of the PRB, and inspections and activities related to 5 year site reviews. It excludes groundwater monitoring and related activities to demonstrate performance of the PRB.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Permeable Reactive Barrier Construction	150,000	SF	$201.00	$30,150,000.00	Refer to Table 6-2c for unit quantity
SUBTOTAL				**$30,150,000.00**	
Contingency (Scope and Bid)	20%			$6,030,000	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$36,180,000	
Project Management	5%			$1,809,000	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$2,170,800	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$2,170,800	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$5,427,000	Middle value of recommended range was used.
TOTAL				$47,757,600	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$47,758,000**	Estimated capital cost rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 10, 20, 30, 40, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Permeable Reactive Barrier Repair/Maintenance	37,500	SF	$201.00	$7,537,500.00	Refer to Table 6-2c for unit quantity
SUBTOTAL				**$7,537,500**	
Contingency (Scope and Bid)	20%			$1,507,500	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$9,045,000	
Project Management	5%			$452,250	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,356,750	Middle value of recommended range was used.
TOTAL				$10,854,000	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$10,854,000**	Estimated periodic cost rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				**$50,000**	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost rounded to the nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.

Percentages for contingency and professional/technical services based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000

Abbreviations:

AC	Acre	QTY	Quantity	SF	Square Foot
BCY	Bank Cubic Yard	YR	Year		
LCY	Loose Cubic Yard	LS	Lump Sum		

TABLE 6-2b. In-Situ Groundwater Treatment Using a Permeable Reactive Barrier

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$47,758,000	$0	$0	$47,758,000	1.0000	$47,758,000
1	$0	$0	$0	$0	0.9346	$0
2	$0	$0	$0	$0	0.8734	$0
3	$0	$0	$0	$0	0.8163	$0
4	$0	$0	$0	$0	0.7629	$0
5	$0	$0	$75,000	$75,000	0.7130	$53,475
6	$0	$0	$0	$0	0.6663	$0
7	$0	$0	$0	$0	0.6227	$0
8	$0	$0	$0	$0	0.5820	$0
9	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$10,929,000	$10,929,000	0.5083	$5,555,211
11	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$75,000	$75,000	0.3624	$27,180
16	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$10,929,000	$10,929,000	0.2584	$2,824,054
21	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$75,000	$75,000	0.1842	$13,815
26	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$10,929,000	$10,929,000	0.1314	$1,436,071
31	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$75,000	$75,000	0.0937	$7,028
36	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$10,929,000	$10,929,000	0.0668	$730,057
41	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$75,000	$75,000	0.0476	$3,570
46	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$10,929,000	$10,929,000	0.0339	$370,493
TOTALS:	$47,758,000	$0	$55,020,000	**$102,778,000**		$58,778,954
TOTAL PRESENT VALUE[5]						**$58,779,000**

Notes:
[1] Duration is assumed to be 50 years for present value analysis.
[2] Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000.

TABLE 6-3a. Ex-Situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

Ex Situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

SCREENING COST ESTIMATE SUMMARY

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a water treatment plant capable of treating arsenic-contaminated water at 8 cubic feet per ssecond (cfs), related annual O&M activities, and inspections and activities related to 5 year site reviews. It excludes the collection, storage, pumping, and utility systems needed to transfer water to the treatment plant and O&M of those systems, which could substantially add to cost.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Construction	1	LS	$15,000,000.00	$15,000,000.00	Refer to Table 6-3c for unit quantity
SUBTOTAL				$15,000,000.00	
Contingency (Scope and Bid)	25%			$3,750,000	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$18,750,000	
Project Management	5%			$937,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$2,812,500	Middle value of the recommended range was used.
TOTAL				$24,750,000	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$24,750,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
WTP Operational Costs (Excluding Ferric Chloride)	1	YR	$1,830,137.00	$1,830,137.00	Refer to Table 6-3c for unit quantity
WTP Treatment Media (Ferric Chloride)	1	YR	$1,969,151.92	$1,969,152.00	
SUBTOTAL				$3,799,289	
Contingency (Scope and Bid)	25%			$949,822	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$4,749,111	
Project Management	5%			$237,456	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$712,367	Middle value of the recommended range was used.
TOTAL				$5,698,934	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$5,699,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEAR 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Replacement	1	LS	$15,000,000.00	$15,000,000.00	Refer to Table SCS-Notes
SUBTOTAL				$15,000,000	
Contingency (Scope and Bid)	25%			$3,750,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$18,750,000	
Project Management	5%			$937,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$2,812,500	Middle value of the recommended range was used.
TOTAL				$24,750,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$24,750,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				$50,000	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of the recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost is rounded to the nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.
Percentages used for contingency and professional/technical services are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

YR	Year	QTY	Quantity	SF	Square Foot	LS	Lump Sum

TABLE 6-3b. Ex-situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$24,750,000	$0	$0	$24,750,000	1.0000	$24,750,000
1	$0	$5,699,000	$0	$5,699,000	0.9346	$5,326,285
2	$0	$5,699,000	$0	$5,699,000	0.8734	$4,977,507
3	$0	$5,699,000	$0	$5,699,000	0.8163	$4,652,094
4	$0	$5,699,000	$0	$5,699,000	0.7629	$4,347,767
5	$0	$5,699,000	$75,000	$5,774,000	0.7130	$4,116,862
6	$0	$5,699,000	$0	$5,699,000	0.6663	$3,797,244
7	$0	$5,699,000	$0	$5,699,000	0.6227	$3,548,767
8	$0	$5,699,000	$0	$5,699,000	0.5820	$3,316,818
9	$0	$5,699,000	$0	$5,699,000	0.5439	$3,099,686
10	$0	$5,699,000	$75,000	$5,774,000	0.5083	$2,934,924
11	$0	$5,699,000	$0	$5,699,000	0.4751	$2,707,595
12	$0	$5,699,000	$0	$5,699,000	0.4440	$2,530,356
13	$0	$5,699,000	$0	$5,699,000	0.4150	$2,365,085
14	$0	$5,699,000	$0	$5,699,000	0.3878	$2,210,072
15	$0	$5,699,000	$75,000	$5,774,000	0.3624	$2,092,498
16	$0	$5,699,000	$0	$5,699,000	0.3387	$1,930,251
17	$0	$5,699,000	$0	$5,699,000	0.3166	$1,804,303
18	$0	$5,699,000	$0	$5,699,000	0.2959	$1,686,334
19	$0	$5,699,000	$0	$5,699,000	0.2765	$1,575,774
20	$0	$5,699,000	$75,000	$5,774,000	0.2584	$1,492,002
21	$0	$5,699,000	$0	$5,699,000	0.2415	$1,376,309
22	$0	$5,699,000	$0	$5,699,000	0.2257	$1,286,264
23	$0	$5,699,000	$0	$5,699,000	0.2109	$1,201,919
24	$0	$5,699,000	$0	$5,699,000	0.1971	$1,123,273
25	$0	$5,699,000	$75,000	$5,774,000	0.1842	$1,063,571
26	$0	$5,699,000	$0	$5,699,000	0.1722	$981,368
27	$0	$5,699,000	$0	$5,699,000	0.1609	$916,969
28	$0	$5,699,000	$0	$5,699,000	0.1504	$857,130
29	$0	$5,699,000	$0	$5,699,000	0.1406	$801,279
30	$0	$5,699,000	$75,000	$5,774,000	0.1314	$758,704
31	$0	$5,699,000	$0	$5,699,000	0.1228	$699,837
32	$0	$5,699,000	$0	$5,699,000	0.1147	$653,675
33	$0	$5,699,000	$0	$5,699,000	0.1072	$610,933
34	$0	$5,699,000	$0	$5,699,000	0.1002	$571,040
35	$0	$5,699,000	$75,000	$5,774,000	0.0937	$541,024
36	$0	$5,699,000	$0	$5,699,000	0.0875	$498,663
37	$0	$5,699,000	$0	$5,699,000	0.0818	$466,178
38	$0	$5,699,000	$0	$5,699,000	0.0765	$435,974
39	$0	$5,699,000	$0	$5,699,000	0.0715	$407,479
40	$0	$5,699,000	$75,000	$5,774,000	0.0668	$385,703
41	$0	$5,699,000	$0	$5,699,000	0.0624	$355,618
42	$0	$5,699,000	$0	$5,699,000	0.0583	$332,252
43	$0	$5,699,000	$0	$5,699,000	0.0545	$310,596
44	$0	$5,699,000	$0	$5,699,000	0.0509	$290,079
45	$0	$5,699,000	$75,000	$5,774,000	0.0476	$274,842
46	$0	$5,699,000	$0	$5,699,000	0.0445	$253,606
47	$0	$5,699,000	$0	$5,699,000	0.0416	$237,078
48	$0	$5,699,000	$0	$5,699,000	0.0389	$221,691
49	$0	$5,699,000	$0	$5,699,000	0.0363	$206,874
50	$0	$5,699,000	$24,825,000	$30,524,000	0.0339	$1,034,764
TOTALS:	$24,750,000	$284,950,000	$25,500,000	**$335,200,000**		$104,416,916
			TOTAL PRESENT VALUE[5]			**$104,417,000**

Notes:
1 Duration is assumed to be 50 years for present value analysis.
2 Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000.

TABLE 6-4a. Ex-Situ Treatment of Contaminated Groundwater (5 cfs)

SCREENING COST ESTIMATE SUMMARY

Ex Situ Treatment of Contaminated Groundwater (5 cfs)

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a water treatment plant capable of treating arsenic-contaminated water at 5 cubic feet per ssecond (cfs), related annual O&M activities, and inspections and activities related to 5 year site reviews. It excludes the collection, storage, pumping, and utility systems needed to transfer water to the treatment plant and O&M of those systems, which could substantially add to cost.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Construction	1	LS	$9,000,000.00	$9,000,000.00	Refer to Table 6-4c for unit quantity
SUBTOTAL				$9,000,000.00	
Contingency (Scope and Bid)	25%			$2,250,000	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$11,250,000	
Project Management	5%			$562,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$675,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$675,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,687,500	Middle value of the recommended range was used.
TOTAL				$14,850,000	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$14,850,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
WTP Operational Costs (Excluding Ferric Chloride)	1	YR	$1,830,137.00	$1,830,137.00	Refer to Table 6-4c for unit quantity
WTP Treatment Media (Ferric Chloride)	1	YR	$1,230,719.95	$1,230,720.00	
SUBTOTAL				$3,060,857	
Contingency (Scope and Bid)	25%			$765,214	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$3,826,071	
Project Management	5%			$191,304	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$573,911	Middle value of the recommended range was used.
TOTAL				$4,591,286	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$4,591,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEAR 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Replacement	1	LS	$9,000,000.00	$9,000,000.00	Refer to Table SCS-Notes
SUBTOTAL				$9,000,000	
Contingency (Scope and Bid)	25%			$2,250,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$11,250,000	
Project Management	5%			$562,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$675,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$675,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,687,500	Middle value of the recommended range was used.
TOTAL				$14,850,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$14,850,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				$50,000	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of the recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost is rounded to the nearest $1,000.

Note:
Refer to Table SCS-Notes for cost sources and explanation for various unit costs.
Percentages used for contingency and professional/technical services are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

YR	Year	QTY	Quantity	SF	Square Foot	LS	Lump Sum

TABLE 6-4b. Ex-situ Treatment of Contaminated Groundwater (5 cfs)

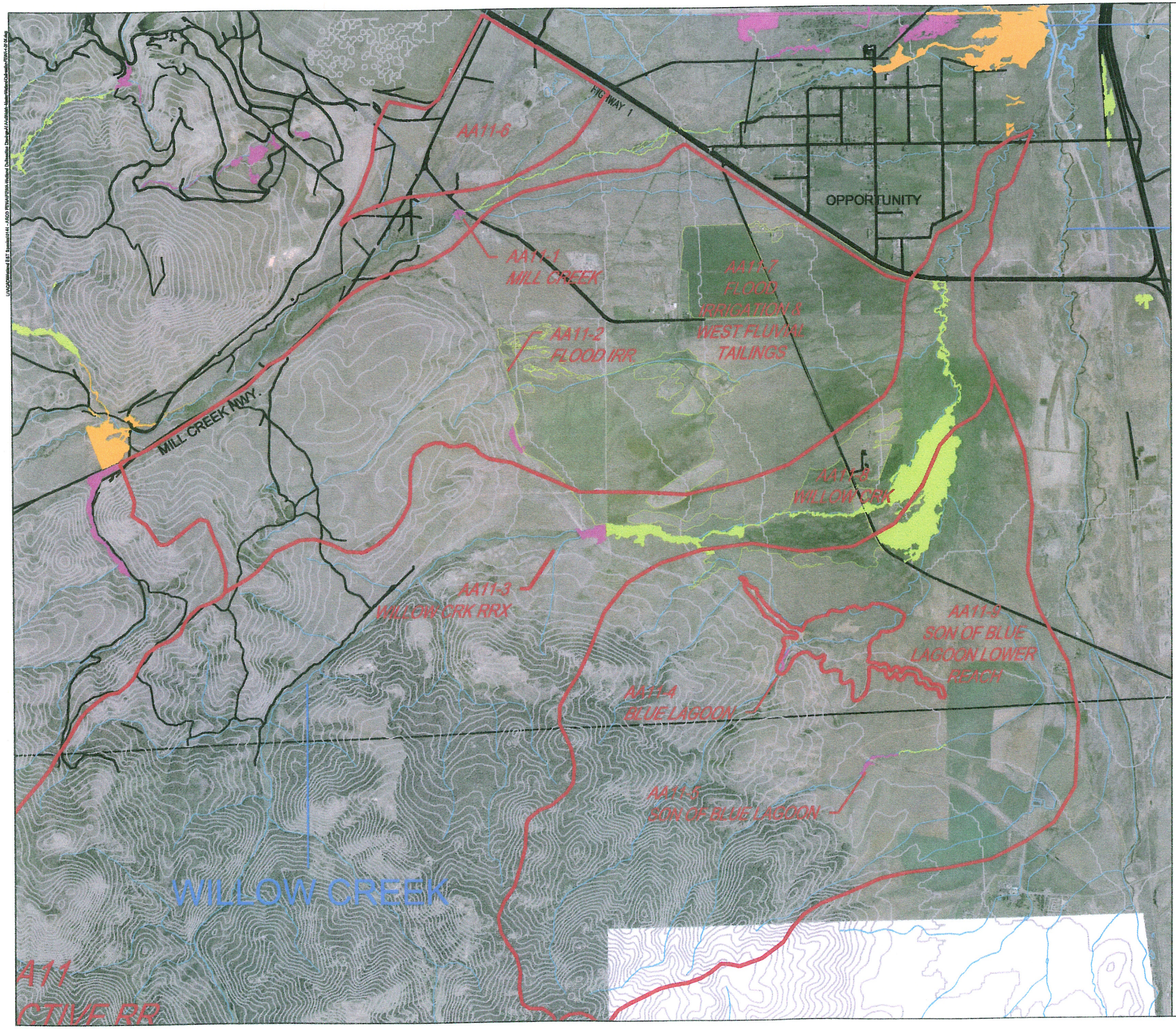
PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$14,850,000	$0	$0	$14,850,000	1.0000	$14,850,000
1	$0	$4,591,000	$0	$4,591,000	0.9346	$4,290,749
2	$0	$4,591,000	$0	$4,591,000	0.8734	$4,009,779
3	$0	$4,591,000	$0	$4,591,000	0.8163	$3,747,633
4	$0	$4,591,000	$0	$4,591,000	0.7629	$3,502,474
5	$0	$4,591,000	$75,000	$4,666,000	0.7130	$3,326,858
6	$0	$4,591,000	$0	$4,591,000	0.6663	$3,058,983
7	$0	$4,591,000	$0	$4,591,000	0.6227	$2,858,816
8	$0	$4,591,000	$0	$4,591,000	0.5820	$2,671,962
9	$0	$4,591,000	$0	$4,591,000	0.5439	$2,497,045
10	$0	$4,591,000	$75,000	$4,666,000	0.5083	$2,371,728
11	$0	$4,591,000	$0	$4,591,000	0.4751	$2,181,184
12	$0	$4,591,000	$0	$4,591,000	0.4440	$2,038,404
13	$0	$4,591,000	$0	$4,591,000	0.4150	$1,905,265
14	$0	$4,591,000	$0	$4,591,000	0.3878	$1,780,390
15	$0	$4,591,000	$75,000	$4,666,000	0.3624	$1,690,958
16	$0	$4,591,000	$0	$4,591,000	0.3387	$1,554,972
17	$0	$4,591,000	$0	$4,591,000	0.3166	$1,453,511
18	$0	$4,591,000	$0	$4,591,000	0.2959	$1,358,477
19	$0	$4,591,000	$0	$4,591,000	0.2765	$1,269,412
20	$0	$4,591,000	$75,000	$4,666,000	0.2584	$1,205,694
21	$0	$4,591,000	$0	$4,591,000	0.2415	$1,108,727
22	$0	$4,591,000	$0	$4,591,000	0.2257	$1,036,189
23	$0	$4,591,000	$0	$4,591,000	0.2109	$968,242
24	$0	$4,591,000	$0	$4,591,000	0.1971	$904,886
25	$0	$4,591,000	$75,000	$4,666,000	0.1842	$859,477
26	$0	$4,591,000	$0	$4,591,000	0.1722	$790,570
27	$0	$4,591,000	$0	$4,591,000	0.1609	$738,692
28	$0	$4,591,000	$0	$4,591,000	0.1504	$690,486
29	$0	$4,591,000	$0	$4,591,000	0.1406	$645,495
30	$0	$4,591,000	$75,000	$4,666,000	0.1314	$613,112
31	$0	$4,591,000	$0	$4,591,000	0.1228	$563,775
32	$0	$4,591,000	$0	$4,591,000	0.1147	$526,588
33	$0	$4,591,000	$0	$4,591,000	0.1072	$492,155
34	$0	$4,591,000	$0	$4,591,000	0.1002	$460,018
35	$0	$4,591,000	$75,000	$4,666,000	0.0937	$437,204
36	$0	$4,591,000	$0	$4,591,000	0.0875	$401,713
37	$0	$4,591,000	$0	$4,591,000	0.0818	$375,544
38	$0	$4,591,000	$0	$4,591,000	0.0765	$351,212
39	$0	$4,591,000	$0	$4,591,000	0.0715	$328,257
40	$0	$4,591,000	$75,000	$4,666,000	0.0668	$311,689
41	$0	$4,591,000	$0	$4,591,000	0.0624	$286,478
42	$0	$4,591,000	$0	$4,591,000	0.0583	$267,655
43	$0	$4,591,000	$0	$4,591,000	0.0545	$250,210
44	$0	$4,591,000	$0	$4,591,000	0.0509	$233,682
45	$0	$4,591,000	$75,000	$4,666,000	0.0476	$222,102
46	$0	$4,591,000	$0	$4,591,000	0.0445	$204,300
47	$0	$4,591,000	$0	$4,591,000	0.0416	$190,986
48	$0	$4,591,000	$0	$4,591,000	0.0389	$178,590
49	$0	$4,591,000	$0	$4,591,000	0.0363	$166,653
50	$0	$4,591,000	$14,925,000	$19,516,000	0.0339	$661,592
TOTALS:	$14,850,000	$229,550,000	$15,600,000	**$260,000,000**		$78,890,573
			TOTAL PRESENT VALUE[5]			**$78,891,000**

Notes:
1 Duration is assumed to be 50 years for present value analysis.
2 Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000.

Appendix A



LEGEND

- Assessment Area Boundary
- Existing Topography *(50' Contours)*
- Waterbodies, Creeks & Ditches
- 2003 Delineated Wetlands
- 2004 Delineated Wetlands
- 2005 Delineated Wetlands
- 1999 FEWA Confirmation

NOTES:

AREA INCLUDES:

AA11-4 = BLUE LAGOON
AA11-6 = SOUTH OPPORTUNITY UPLANDS
AA11-7 = FLOOD IRRIGATION & WEST FLUVIAL TAILINGS
AA11-8 = WILLOW CREEK & WEST FLUVIAL TAILINGS
AA11-9 = SON OF BLUE LAGOON LOWER REACH

AA11-1 = MILL CREEK RR X- ING ABSORBED INTO AA17-2
AA11-2 = FLOODPLAIN IRRIGATION RR X- ING ABSORBED INTO AA11-7
AA11-3 = WILLOW CREEK RR X- ING ABSORBED INTO AA11-8
AA11-5 = SON OF BLUE LAGOON RR X- ING ABSORBED INTO AA11-9

1999 FEWA DATA WAS USED AND MODIFIED AS PER FIELD CONDITIONS FOR AA11-7 FLOOD IRRIGATED PASTURES/WETLANDS.

AA 11 IS PART OF ACTIVE RAILROAD/BLUE LAGOON (RDU5), SOUTH OPPORTUNITY UPLANDS (RDU6), AND FLUVIAL TAILINGS (RDU9)

WETLAND DELINEATION PERFORMED BY WALSH ENVIRONMENTAL IN JULY AND AUGUST, 2003 AND COMPLETED IN MAY, JUNE AND JULY 2005.

REFER TO REVISED FEWA ASSESSMENTS.

BASE MAPPING AND AERIAL PHOTOGRAPHY PROVIDED BY PIONEER TECHNICAL SERVICES, 2003.

FEWA ASSESSMENT - WETLAND SUMMARY TABLE

FEWA AA	WETLAND ACRES	FEWA RATING	FEWA ACRES
11-4	0.88	1.86	0.55
11-6	0.00	0.00	0.00
11-7	1594.72	1.82	967.46
11-8	163.60	2.05	111.79
11-9	2.16	1.14	0.82
TOTAL	**1761.36**		**1080.62**

0 1500 3000 4500
GRAPHIC SCALE

FIGURE AA11

WETLAND DELINEATION
FEWA ASSESSMENT AREA 11

2005FEWA ASSESSMENT
5144-040

DESIGNED BY: J. Dauzvardis, G. Gurnee'
DATE: 11-03, 1-06

Walsh
Environmental Scientists and Engineers, LLC

Appendix B

Technology Evaluation Screening Cost Estimate Spreadsheets

The screening cost spreadsheets were developed in accordance with EPA Directive 9234.2-25 (September 1993) and EPA 540-R-00-002 (OSWER 9355.0-75) July 2000.

These screening costs should be used to compare relative costs between remedial technologies and/or strategies for purposes of the Technical Impracticability evaluations. Costs for project management, remedial design, and construction management were determined as percentages of capital cost per the EPA 540-R-00-002 guidance. Costs for these work items may not reflect costs for implementation. These costs are determined based on specific client requirements during implementation.

Screening Cost Estimate Summaries

TABLE 6-1a. Contaminated Soil Removal and Disposal

SCREENING COST ESTIMATE SUMMARY

Contaminated Soil Removal and Disposal

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes cremoval of arsenic-contaminated soil, disposal of the contaminated soil at the Opportunity ponds waste management area (WMA) and related O&M of the consoldiated wastes, development of a borrow source and backfilling the excavation with clean soil, and inspections and activities related to 5 year site reviews.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Contaminant Source Removal, Transport, and Consolidation at the Opportunity Ponds WMA	4,053,500	BCY	$10.00	$40,535,000.00	Refer to Table 6-1c for unit quantity
Borrow Area Development, Hauling, and Placement	4,539,920	LCY	$15.00	$68,098,800.00	Refer to Table 6-1c for unit quantity
Seed Bed Preparation and Fertilization	3,715	AC	$1,000.00	$3,715,000.00	Refer to Table 6-1c for unit quantity
Organic Matter Addition	3,215	AC	$750.00	$2,411,250.00	Refer to Table 6-1c for unit quantity
SUBTOTAL				**$114,760,050.00**	
Contingency (Scope and Bid)	25%			$28,690,013	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$143,450,063	
Project Management	5%			$7,172,503	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$8,607,004	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$8,607,004	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$21,517,509	Middle value of the recommended range was used.
TOTAL				$189,354,083	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$189,354,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS (Years 1 through 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Seed Bed Preparation and Fertilization	25	AC	$1,000.00	$25,000.00	Refer to Table 6-1c for unit quantity
SUBTOTAL				**$25,000**	
Contingency (Scope and Bid)	25%			$6,250	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$31,250	
Project Management	10%			$3,125	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$4,688	Middle value of the recommended range was used.
TOTAL				$39,063	
ESTIMATED ANNUAL O&M COST FOR MAJOR REMEDY COMPONENTS				**$39,000**	Estimated annual O&M cost rounded to nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				**$50,000**	
Contingency (Scope and Bid)	25%			$12,500	15% Scope, 10% Bid (Low end of recommended range).
SUBTOTAL				$62,500	
Project Management	10%			$6,250	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,375	Middle value of recommended range was used.
TOTAL				$78,125	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$78,000**	Estimated periodic cost rounded to nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.
Percentages for contingency and professional/technical services based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

AC	Acre	QTY	Quantity
BCY	Bank Cubic Yard	YR	Year
LCY	Loose Cubic Yard	LS	Lump Sum

TABLE 6-2a. In-Situ Groundwater Treatment Using a Permeable Reactive Barrier

SCREENING COST ESTIMATE SUMMARY

In Situ Groundwater Treatment Using a Permeable Reactive Barrier

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a permeable reactive barrier (PRB) capable of treating arsenic-contaminated water in situ, related repair and maintenance of the PRB, and inspections and activities related to 5 year site reviews. It excludes groundwater monitoring and related activities to demonstrate performance of the PRB.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Permeable Reactive Barrier Construction	150,000	SF	$201.00	$30,150,000.00	Refer to Table 6-2c for unit quantity
SUBTOTAL				**$30,150,000.00**	
Contingency (Scope and Bid)	20%			$6,030,000	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$36,180,000	
Project Management	5%			$1,809,000	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$2,170,800	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$2,170,800	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$5,427,000	Middle value of recommended range was used.
TOTAL				$47,757,600	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$47,758,000**	Estimated capital cost rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 10, 20, 30, 40, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Permeable Reactive Barrier Repair/Maintenance	37,500	SF	$201.00	$7,537,500.00	Refer to Table 6-2c for unit quantity
SUBTOTAL				**$7,537,500**	
Contingency (Scope and Bid)	20%			$1,507,500	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$9,045,000	
Project Management	5%			$452,250	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,356,750	Middle value of recommended range was used.
TOTAL				$10,854,000	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$10,854,000**	Estimated periodic cost rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				**$50,000**	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of recommended range)
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost rounded to the nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.

Percentages for contingency and professional/technical services based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000

Abbreviations:

AC	Acre	QTY	Quantity	SF	Square Foot
BCY	Bank Cubic Yard	YR	Year		
LCY	Loose Cubic Yard	LS	Lump Sum		

TABLE 6-3a. Ex-Situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

Ex Situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

SCREENING COST ESTIMATE SUMMARY

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a water treatment plant capable of treating arsenic-contaminated water at 8 cubic feet per ssecond (cfs), related annual O&M activities, and inspections and activities related to 5 year site reviews. It excludes the collection, storage, pumping, and utility systems needed to transfer water to the treatment plant and O&M of those systems, which could substantially add to cost.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Construction	1	LS	$15,000,000.00	$15,000,000.00	Refer to Table 6-3c for unit quantity
SUBTOTAL				$15,000,000.00	
Contingency (Scope and Bid)	25%			$3,750,000	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$18,750,000	
Project Management	5%			$937,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$2,812,500	Middle value of the recommended range was used.
TOTAL				$24,750,000	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$24,750,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
WTP Operational Costs (Excluding Ferric Chloride)	1	YR	$1,830,137.00	$1,830,137.00	Refer to Table 6-3c for unit quantity
WTP Treatment Media (Ferric Chloride)	1	YR	$1,969,151.92	$1,969,152.00	
SUBTOTAL				$3,799,289	
Contingency (Scope and Bid)	25%			$949,822	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$4,749,111	
Project Management	5%			$237,456	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$712,367	Middle value of the recommended range was used.
TOTAL				$5,698,934	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$5,699,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEAR 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Replacement	1	LS	$15,000,000.00	$15,000,000.00	Refer to Table SCS-Notes
SUBTOTAL				$15,000,000	
Contingency (Scope and Bid)	25%			$3,750,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$18,750,000	
Project Management	5%			$937,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$1,125,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$2,812,500	Middle value of the recommended range was used.
TOTAL				$24,750,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$24,750,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				$50,000	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of the recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost is rounded to the nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.
Percentages used for contingency and professional/technical services are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

YR	Year	QTY	Quantity	SF	Square Foot	LS	Lump Sum

TABLE 6-4a. Ex-Situ Treatment of Contaminated Groundwater (5 cfs)

SCREENING COST ESTIMATE SUMMARY

Ex Situ Treatment of Contaminated Groundwater (5 cfs)

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluation
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

MAJOR REMEDY COMPONENTS DESCRIPTION:

This estimate includes construction of a water treatment plant capable of treating arsenic-contaminated water at 5 cubic feet per ssecond (cfs), related annual O&M activities, and inspections and activities related to 5 year site reviews. It excludes the collection, storage, pumping, and utility systems needed to transfer water to the treatment plant and O&M of those systems, which could substantially add to cost.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Construction	1	LS	$9,000,000.00	$9,000,000.00	Refer to Table 6-4c for unit quantity
SUBTOTAL				$9,000,000.00	
Contingency (Scope and Bid)	25%			$2,250,000	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$11,250,000	
Project Management	5%			$562,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$675,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$675,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,687,500	Middle value of the recommended range was used.
TOTAL				$14,850,000	
ESTIMATED CAPITAL COST FOR MAJOR REMEDY COMPONENTS				**$14,850,000**	Estimated capital cost is rounded to the nearest $1,000.

ANNUAL O&M COSTS:

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
WTP Operational Costs (Excluding Ferric Chloride)	1	YR	$1,830,137.00	$1,830,137.00	Refer to Table 6-4c for unit quantity
WTP Treatment Media (Ferric Chloride)	1	YR	$1,230,719.95	$1,230,720.00	
SUBTOTAL				$3,060,857	
Contingency (Scope and Bid)	25%			$765,214	15% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$3,826,071	
Project Management	5%			$191,304	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$573,911	Middle value of the recommended range was used.
TOTAL				$4,591,286	
ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$4,591,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEAR 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Water Treatment Plant Replacement	1	LS	$9,000,000.00	$9,000,000.00	Refer to Table SCS-Notes
SUBTOTAL				$9,000,000	
Contingency (Scope and Bid)	25%			$2,250,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$11,250,000	
Project Management	5%			$562,500	Percentage from Exhibit 5-8 was used.
Remedial Design	6%			$675,000	Percentage from Exhibit 5-8 was used.
Construction Management	6%			$675,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$1,687,500	Middle value of the recommended range was used.
TOTAL				$14,850,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$14,850,000**	Estimated periodic cost is rounded to the nearest $1,000.

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50):

DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Inspections and 5 Year Site Reviews	1	LS	$50,000.00	$50,000.00	Refer to Table SCS-Notes
SUBTOTAL				$50,000	
Contingency (Scope and Bid)	20%			$10,000	10% Scope, 10% Bid (Low end of the recommended range).
SUBTOTAL				$60,000	
Project Management	10%			$6,000	Percentage from Exhibit 5-8 was used.
Technical Support	15%			$9,000	Middle value of the recommended range was used.
TOTAL				$75,000	
TOTAL ESTIMATED PERIODIC COST FOR MAJOR REMEDY COMPONENTS				**$75,000**	Estimated periodic cost is rounded to the nearest $1,000.

Note:

Refer to Table SCS-Notes for cost sources and explanation for various unit costs.

Percentages used for contingency and professional/technical services are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Abbreviations:

YR	Year	QTY	Quantity	SF	Square Foot	LS	Lump Sum

Present Value Analyses
for Screening Cost Estimates

TABLE 6-1b. Contaminated Soil Removal and Disposal

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$189,354,000	$0	$0	$189,354,000	1.0000	$189,354,000
1	$0	$39,000	$0	$39,000	0.9346	$36,449
2	$0	$39,000	$0	$39,000	0.8734	$34,063
3	$0	$39,000	$0	$39,000	0.8163	$31,836
4	$0	$39,000	$0	$39,000	0.7629	$29,753
5	$0	$39,000	$78,000	$117,000	0.7130	$83,421
6	$0	$39,000	$0	$39,000	0.6663	$25,986
7	$0	$39,000	$0	$39,000	0.6227	$24,285
8	$0	$39,000	$0	$39,000	0.5820	$22,698
9	$0	$39,000	$0	$39,000	0.5439	$21,212
10	$0	$39,000	$78,000	$117,000	0.5083	$59,471
11	$0	$39,000	$0	$39,000	0.4751	$18,529
12	$0	$39,000	$0	$39,000	0.4440	$17,316
13	$0	$39,000	$0	$39,000	0.4150	$16,185
14	$0	$39,000	$0	$39,000	0.3878	$15,124
15	$0	$39,000	$78,000	$117,000	0.3624	$42,401
16	$0	$39,000	$0	$39,000	0.3387	$13,209
17	$0	$39,000	$0	$39,000	0.3166	$12,347
18	$0	$39,000	$0	$39,000	0.2959	$11,540
19	$0	$39,000	$0	$39,000	0.2765	$10,784
20	$0	$39,000	$78,000	$117,000	0.2584	$30,233
21	$0	$39,000	$0	$39,000	0.2415	$9,419
22	$0	$39,000	$0	$39,000	0.2257	$8,802
23	$0	$39,000	$0	$39,000	0.2109	$8,225
24	$0	$39,000	$0	$39,000	0.1971	$7,687
25	$0	$39,000	$78,000	$117,000	0.1842	$21,551
26	$0	$39,000	$0	$39,000	0.1722	$6,716
27	$0	$39,000	$0	$39,000	0.1609	$6,275
28	$0	$39,000	$0	$39,000	0.1504	$5,866
29	$0	$39,000	$0	$39,000	0.1406	$5,483
30	$0	$39,000	$78,000	$117,000	0.1314	$15,374
31	$0	$39,000	$0	$39,000	0.1228	$4,789
32	$0	$39,000	$0	$39,000	0.1147	$4,473
33	$0	$39,000	$0	$39,000	0.1072	$4,181
34	$0	$39,000	$0	$39,000	0.1002	$3,908
35	$0	$39,000	$78,000	$117,000	0.0937	$10,963
36	$0	$39,000	$0	$39,000	0.0875	$3,413
37	$0	$39,000	$0	$39,000	0.0818	$3,190
38	$0	$39,000	$0	$39,000	0.0765	$2,984
39	$0	$39,000	$0	$39,000	0.0715	$2,789
40	$0	$39,000	$78,000	$117,000	0.0668	$7,816
41	$0	$39,000	$0	$39,000	0.0624	$2,434
42	$0	$39,000	$0	$39,000	0.0583	$2,274
43	$0	$39,000	$0	$39,000	0.0545	$2,126
44	$0	$39,000	$0	$39,000	0.0509	$1,985
45	$0	$39,000	$78,000	$117,000	0.0476	$5,569
46	$0	$39,000	$0	$39,000	0.0445	$1,736
47	$0	$39,000	$0	$39,000	0.0416	$1,622
48	$0	$39,000	$0	$39,000	0.0389	$1,517
49	$0	$39,000	$0	$39,000	0.0363	$1,416
50	$0	$39,000	$78,000	$117,000	0.0339	$3,966
TOTALS:	$189,354,000	$1,950,000	$780,000	**$192,084,000**		$190,079,391
TOTAL PRESENT VALUE [5]						**$190,079,000**

Notes:

[1] Duration is assumed to be 50 years for present value analysis.
[2] Capital costs, for purposes of this screening analysis, are assumed to occur in Year 1.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000.

TABLE 6-2b. In-Situ Groundwater Treatment Using a Permeable Reactive Barrier

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$47,758,000	$0	$0	$47,758,000	1.0000	$47,758,000
1	$0	$0	$0	$0	0.9346	$0
2	$0	$0	$0	$0	0.8734	$0
3	$0	$0	$0	$0	0.8163	$0
4	$0	$0	$0	$0	0.7629	$0
5	$0	$0	$75,000	$75,000	0.7130	$53,475
6	$0	$0	$0	$0	0.6663	$0
7	$0	$0	$0	$0	0.6227	$0
8	$0	$0	$0	$0	0.5820	$0
9	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$10,929,000	$10,929,000	0.5083	$5,555,211
11	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$75,000	$75,000	0.3624	$27,180
16	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$10,929,000	$10,929,000	0.2584	$2,824,054
21	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$75,000	$75,000	0.1842	$13,815
26	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$10,929,000	$10,929,000	0.1314	$1,436,071
31	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$75,000	$75,000	0.0937	$7,028
36	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$10,929,000	$10,929,000	0.0668	$730,057
41	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$75,000	$75,000	0.0476	$3,570
46	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$10,929,000	$10,929,000	0.0339	$370,493
TOTALS:	$47,758,000	$0	$55,020,000	**$102,778,000**		$58,778,954
TOTAL PRESENT VALUE[5]						**$58,779,000**

Notes:
1 Duration is assumed to be 50 years for present value analysis.
2 Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000.

TABLE 6-3b. Ex-situ Treatment of Contaminated Surface Water Collected from Willow Creek (8 cfs)

PRESENT VALUE ANALYSIS

Site:	**South Opportunity Area of Concern, Anaconda Smelter NPL Site**
Location:	**Anaconda, Montana**
Phase:	**Technical Impracticalibility Evaluation**
AACEI Classification:	**Class 5 (Order of Magnitude Estimate) (-50%/+100%)**
Base Year:	**2009**

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$24,750,000	$0	$0	$24,750,000	1.0000	$24,750,000
1	$0	$5,699,000	$0	$5,699,000	0.9346	$5,326,285
2	$0	$5,699,000	$0	$5,699,000	0.8734	$4,977,507
3	$0	$5,699,000	$0	$5,699,000	0.8163	$4,652,094
4	$0	$5,699,000	$0	$5,699,000	0.7629	$4,347,767
5	$0	$5,699,000	$75,000	$5,774,000	0.7130	$4,116,862
6	$0	$5,699,000	$0	$5,699,000	0.6663	$3,797,244
7	$0	$5,699,000	$0	$5,699,000	0.6227	$3,548,767
8	$0	$5,699,000	$0	$5,699,000	0.5820	$3,316,818
9	$0	$5,699,000	$0	$5,699,000	0.5439	$3,099,686
10	$0	$5,699,000	$75,000	$5,774,000	0.5083	$2,934,924
11	$0	$5,699,000	$0	$5,699,000	0.4751	$2,707,595
12	$0	$5,699,000	$0	$5,699,000	0.4440	$2,530,356
13	$0	$5,699,000	$0	$5,699,000	0.4150	$2,365,085
14	$0	$5,699,000	$0	$5,699,000	0.3878	$2,210,072
15	$0	$5,699,000	$75,000	$5,774,000	0.3624	$2,092,498
16	$0	$5,699,000	$0	$5,699,000	0.3387	$1,930,251
17	$0	$5,699,000	$0	$5,699,000	0.3166	$1,804,303
18	$0	$5,699,000	$0	$5,699,000	0.2959	$1,686,334
19	$0	$5,699,000	$0	$5,699,000	0.2765	$1,575,774
20	$0	$5,699,000	$75,000	$5,774,000	0.2584	$1,492,002
21	$0	$5,699,000	$0	$5,699,000	0.2415	$1,376,309
22	$0	$5,699,000	$0	$5,699,000	0.2257	$1,286,264
23	$0	$5,699,000	$0	$5,699,000	0.2109	$1,201,919
24	$0	$5,699,000	$0	$5,699,000	0.1971	$1,123,273
25	$0	$5,699,000	$75,000	$5,774,000	0.1842	$1,063,571
26	$0	$5,699,000	$0	$5,699,000	0.1722	$981,368
27	$0	$5,699,000	$0	$5,699,000	0.1609	$916,969
28	$0	$5,699,000	$0	$5,699,000	0.1504	$857,130
29	$0	$5,699,000	$0	$5,699,000	0.1406	$801,279
30	$0	$5,699,000	$75,000	$5,774,000	0.1314	$758,704
31	$0	$5,699,000	$0	$5,699,000	0.1228	$699,837
32	$0	$5,699,000	$0	$5,699,000	0.1147	$653,675
33	$0	$5,699,000	$0	$5,699,000	0.1072	$610,933
34	$0	$5,699,000	$0	$5,699,000	0.1002	$571,040
35	$0	$5,699,000	$75,000	$5,774,000	0.0937	$541,024
36	$0	$5,699,000	$0	$5,699,000	0.0875	$498,663
37	$0	$5,699,000	$0	$5,699,000	0.0818	$466,178
38	$0	$5,699,000	$0	$5,699,000	0.0765	$435,974
39	$0	$5,699,000	$0	$5,699,000	0.0715	$407,479
40	$0	$5,699,000	$75,000	$5,774,000	0.0668	$385,703
41	$0	$5,699,000	$0	$5,699,000	0.0624	$355,618
42	$0	$5,699,000	$0	$5,699,000	0.0583	$332,252
43	$0	$5,699,000	$0	$5,699,000	0.0545	$310,596
44	$0	$5,699,000	$0	$5,699,000	0.0509	$290,079
45	$0	$5,699,000	$75,000	$5,774,000	0.0476	$274,842
46	$0	$5,699,000	$0	$5,699,000	0.0445	$253,606
47	$0	$5,699,000	$0	$5,699,000	0.0416	$237,078
48	$0	$5,699,000	$0	$5,699,000	0.0389	$221,691
49	$0	$5,699,000	$0	$5,699,000	0.0363	$206,874
50	$0	$5,699,000	$24,825,000	$30,524,000	0.0339	$1,034,764
TOTALS:	$24,750,000	$284,950,000	$25,500,000	**$335,200,000**		$104,416,916
TOTAL PRESENT VALUE[5]						**$104,417,000**

Notes:

[1] Duration is assumed to be 50 years for present value analysis.

[2] Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.

[3] Total annual expenditure is the total cost per year with no discounting.

[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.

[5] Total present value is rounded to the nearest $1,000.

TABLE 6-4b. Ex-situ Treatment of Contaminated Groundwater (5 cfs)

PRESENT VALUE ANALYSIS

Site: South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location: Anaconda, Montana
Phase: Technical Impracticalibility Evaluation
AACEI Classification: Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year: 2009

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$14,850,000	$0	$0	$14,850,000	1.0000	$14,850,000
1	$0	$4,591,000	$0	$4,591,000	0.9346	$4,290,749
2	$0	$4,591,000	$0	$4,591,000	0.8734	$4,009,779
3	$0	$4,591,000	$0	$4,591,000	0.8163	$3,747,633
4	$0	$4,591,000	$0	$4,591,000	0.7629	$3,502,474
5	$0	$4,591,000	$75,000	$4,666,000	0.7130	$3,326,858
6	$0	$4,591,000	$0	$4,591,000	0.6663	$3,058,983
7	$0	$4,591,000	$0	$4,591,000	0.6227	$2,858,816
8	$0	$4,591,000	$0	$4,591,000	0.5820	$2,671,962
9	$0	$4,591,000	$0	$4,591,000	0.5439	$2,497,045
10	$0	$4,591,000	$75,000	$4,666,000	0.5083	$2,371,728
11	$0	$4,591,000	$0	$4,591,000	0.4751	$2,181,184
12	$0	$4,591,000	$0	$4,591,000	0.4440	$2,038,404
13	$0	$4,591,000	$0	$4,591,000	0.4150	$1,905,265
14	$0	$4,591,000	$0	$4,591,000	0.3878	$1,780,390
15	$0	$4,591,000	$75,000	$4,666,000	0.3624	$1,690,958
16	$0	$4,591,000	$0	$4,591,000	0.3387	$1,554,972
17	$0	$4,591,000	$0	$4,591,000	0.3166	$1,453,511
18	$0	$4,591,000	$0	$4,591,000	0.2959	$1,358,477
19	$0	$4,591,000	$0	$4,591,000	0.2765	$1,269,412
20	$0	$4,591,000	$75,000	$4,666,000	0.2584	$1,205,694
21	$0	$4,591,000	$0	$4,591,000	0.2415	$1,108,727
22	$0	$4,591,000	$0	$4,591,000	0.2257	$1,036,189
23	$0	$4,591,000	$0	$4,591,000	0.2109	$968,242
24	$0	$4,591,000	$0	$4,591,000	0.1971	$904,886
25	$0	$4,591,000	$75,000	$4,666,000	0.1842	$859,477
26	$0	$4,591,000	$0	$4,591,000	0.1722	$790,570
27	$0	$4,591,000	$0	$4,591,000	0.1609	$738,692
28	$0	$4,591,000	$0	$4,591,000	0.1504	$690,486
29	$0	$4,591,000	$0	$4,591,000	0.1406	$645,495
30	$0	$4,591,000	$75,000	$4,666,000	0.1314	$613,112
31	$0	$4,591,000	$0	$4,591,000	0.1228	$563,775
32	$0	$4,591,000	$0	$4,591,000	0.1147	$526,588
33	$0	$4,591,000	$0	$4,591,000	0.1072	$492,155
34	$0	$4,591,000	$0	$4,591,000	0.1002	$460,018
35	$0	$4,591,000	$75,000	$4,666,000	0.0937	$437,204
36	$0	$4,591,000	$0	$4,591,000	0.0875	$401,713
37	$0	$4,591,000	$0	$4,591,000	0.0818	$375,544
38	$0	$4,591,000	$0	$4,591,000	0.0765	$351,212
39	$0	$4,591,000	$0	$4,591,000	0.0715	$328,257
40	$0	$4,591,000	$75,000	$4,666,000	0.0668	$311,689
41	$0	$4,591,000	$0	$4,591,000	0.0624	$286,478
42	$0	$4,591,000	$0	$4,591,000	0.0583	$267,655
43	$0	$4,591,000	$0	$4,591,000	0.0545	$250,210
44	$0	$4,591,000	$0	$4,591,000	0.0509	$233,682
45	$0	$4,591,000	$75,000	$4,666,000	0.0476	$222,102
46	$0	$4,591,000	$0	$4,591,000	0.0445	$204,300
47	$0	$4,591,000	$0	$4,591,000	0.0416	$190,986
48	$0	$4,591,000	$0	$4,591,000	0.0389	$178,590
49	$0	$4,591,000	$0	$4,591,000	0.0363	$166,653
50	$0	$4,591,000	$14,925,000	$19,516,000	0.0339	$661,592
TOTALS:	$14,850,000	$229,550,000	$15,600,000	**$260,000,000**		$78,890,573
TOTAL PRESENT VALUE[5]						**$78,891,000**

Notes:
[1] Duration is assumed to be 50 years for present value analysis.
[2] Capital costs, for purposes of this alternative screening analysis, are assumed to occur in Year 1.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table SPV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000.

Calculation Backup Summaries

TABLE SCS-Notes

Unit Cost Basis for Various Work Elements/Activities Within Tables 6-1a through 6-4a

SCREENING COST ESTIMATE SUMMARY

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site
Location:	Anaconda, Montana
Phase:	Technical Impracticalibility Evaluatio
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)
Base Year:	2009
Date:	June 5, 2009

This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.

WORK ELEMENT DESCRIPTION	TABLES	UNIT COST	UNIT(S)	UNIT COST METHODOLOGY	UNIT COST SOURCE	NOTES
Inspection and 5 Year Site Reviews	6-1, 6-2, and 6-3	$50,000.00	LS	Specific Analogy	CERCLA Work for EPA	The annual unit cost is based on projections of inspections and 5-year site review scope based on costs for this work at other sites.
Contaminant Source Removal, Transport, and Consolidation at the Opportunity Ponds WMA	6-1	$10.00	BCY	Specific Analogy	Previous CERCLA Work at the Anaconda Smelter NPL Site	
Borrow Area Development, Hauling, and Placement	6-1	$15.00	LCY			
Seed Bed Preparation and Fertilization	6-1	$1,000.00	AC			
Organic Matter Addition	6-1	$750.00	AC			
Permeable Reactive Barrier Construction	6-2	$201.00	SF	Specific Analogy		Based on average of 4 sources of costs for PRB construction.
Water Treatment Plant Construction (8 cfs); Water Treatment Plant Replacement (8 cfs)	6-3	$15,000,000.00	LS	Parametric Estimating	Based on EPA Guidance (2002)	
WTP Operational Costs (Excluding Ferric Chloride)(8 cfs)	6-3	$1,830,137.00	YR		WTP operational costs at the Summitville NPL Site,	
WTP Treatment Media (Ferric Chloride)(8 cfs)	6-3	$1,969,151.92	YR			
Water Treatment Plant Construction (5 cfs); Water Treatment Plant Replacement (5 cfs)	6-3	$9,000,000.00	LS		EPA Guidance (2002)	
WTP Operational Costs (Excluding Ferric Chloride)(5cfs)	6-3	$1,830,137.00	YR		WTP operational costs at the Summitville NPL Site	
WTP Treatment Media (Ferric Chloride)(5 cfs)	6-3	$1,230,719.95	YR			

Note: Unit costs in this table are rounded to the nearest $1000 (large unit costs) or nearest $1 (small unit costs).

TABLE SCS-Notes

Unit Cost Basis for Various Work Elements/Activities Within Tables 6-1a through 6-4a

SCREENING COST ESTIMATE SUMMARY

Site:	South Opportunity Area of Concern, Anaconda Smelter NPL Site	This estimate was prepared to evaluate remedy option costs for arsenic-contaminated groundwater/surface water at the South Opportunity Area of Concern, Anaconda Smelter NPL Site. The estimate was prepared to meet the cost requirements within Section 4.4.5 of EPA's "Guidance fo Evaluating the Technical Impracticability of Ground-Water Restoration", Dircetive 9234.2-25 (September 1993). The primary purpose of these estimates is to demonstrate capital, O&M, periodic, and present value cost impacts from major remedy components related to these alternate remedial strategies. This estimate is considered to be Class 5 (Order of Magnitude) under AACEI Recommended Practice 18R-97, with an expected accuracy range of -50% to +100% of actual costs. Only major captial, O&M, and periodic costs are provided; not all components necessary to implement a comprehensive remedy are estimated. General cost estimate methodology and presentation for these screening-level cost estimates are based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002, July 2000.
Location:	Anaconda, Montana	
Phase:	Technical Impracticalibility Evaluatio	
AACEI Classification:	Class 5 (Order of Magnitude Estimate) (-50%/+100%)	
Base Year:	2009	
Date:	June 5, 2009	

Abbreviations:

AC	Acre	LS	Lump Sum
BCY	Bank Cubic Yard	NA	Not Applicable
		YR	Year

TABLE SPV-ADRFT

PRESENT VALUE ANALYSIS

Annual Discount Rate Factors Table

Site:	**South Opportunity Area of Concern, Anaconda Smelter NPL Site**
Location:	**Anaconda, Montana**
Phase:	**Technical Impracticalibility Evaluation**
AACEI Classification:	**Class 5 (Order of Magnitude Estimate) (-50%/+100%)**
Base Year:	**2009**

Discount Rate (Percent): 7.0

Year	Discount Factor[1,2]	Year	Discount Factor[1,2]
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

1 Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

2 The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5.

Table 6-1c
Soil Removal and Replacement Cost Estimate Calculations and Assumptions

Purpose:

This cost estimate is based on the premise that removing surficial soils with elevated arsenic concentrations will allow ground water concentrations to eventually attenuate to below the human health standard.

Major Assumptions:

- Soils will be hauled to the Opportunity Ponds for disposal
- Replacement soil will be hauled from an assumed borrow location near Fairmont (10 miles haul).
- Acreage is assumed from the delineation of the South Opportunity ground water plume (2,807 acres).
- Additional acreage is assumed in wetland areas where arsenic contamination is suspected (368 acres).
- Residential areas and roads are excluded from acreage estimate (160 acres).
- Depth of removal assumed from arsenic contamination depth (10 inches)
- Unit costs based on similar projects completed in the Anaconda area.
- Revegetation costs assume seedbed preparation, fertilizer, and seed for all disturbed areas
- No organic matter necessary for removed soils disposed in the Opportunity Ponds (removed soils are topsoils)

Removal Area		
Known arsenic ground water contamination (see Figure 2-4)	2,807	acres
Minus roads	70	acres
Minus houses and yards	30	acres
Minus stream bed	60	acres
Net	2,647	acres
Add wetlands outside known ground water contamination:		
Town of Opportunity area wetlands	160	acres
South Fork Willow Creek area wetlands	208	acres
Total Removal Area	**3,015**	**acres**
Removal Volume		
Depth of Soil Removal	10	inches
Volume of soil removal	**4,053,500**	**BCY**
Volume of soil removal, assuming 12% swell factor	**4,539,920**	**LCY**
Borrow and Disposal Areas		
Assumed borrow area disturbance	200	acres
Estimated depth of borrow area	13	feet
Assumed soil disposal area, Opportunity Ponds	500	acres
Estimated depth of soil placement at Opportunity Ponds	6	feet
Revegetation		
Acreage requiring revegetation (removal+borrow+disposal areas)	**3,715**	**acres**
Acreage requiring organic matter (removal + borrow areas)	**3,215**	**acres**
O&M of Waste Cover at Opportunity Pond WMA		
Acreage requiring revegetation (assume 5% of disposal area annually)	**25**	**acres**

Table 6-2c
Permeable Reactive Barrier Cost Estimate Calculations and Assumptions

Methodology and Assumptions:

			Notes:
Length	15,000	linear feet	See Note 1
Depth	10	feet	See Note 2
Material	50/50 Mixture of Zero Valent Iron and Sand, 3 feet thick		

Survey of Capital Costs for Permeable Reactive Barriers:

Unit cost per square foot				Notes:	
$	220			See Note 3	
$	139			See Note 4	
$	155			See Note 4	
	30.48%	Escalation Factor		See Note 5	
Average per square foot unit cost, 2008 dollars				**$**	**201**
Total Cost (based on square feet)				**$**	**30,180,793**
Design and Construction			20%	$	6,036,159
Subtotal				**$**	**36,216,951**
Contingency			20%	$	7,243,390
Total Capital Cost				**$**	**43,500,000**

Periodic O&M - Assume Every 10 years at 25% of initial capital cost (see Note 6)

	Periodic Cost		**Discount Factor (7%)**	**Present Value Cost**	
Year 10	**$**	**10,875,000**	0.508	$	5,524,500
Year 20	**$**	**10,875,000**	0.258	$	2,805,750
Year 30	**$**	**10,875,000**	0.131	$	1,424,625
Total O&M				**$**	**9,800,000**
Total Cost				**$**	**53,300,000**

Notes:

1. From crossing at Crackerville Road to crossing at Highway 1, then parallel to Highway 1 (see Figure 6-1)
2. Depth to treat arsenic in top portion of aquifer
3. CDM EE/CA, client confidential (2008)
4. EPA 2002. EPA Roundtable Technical Group Survey
5. Escalation factor from USACE CWCCIS (2008) to adjust EPA 2002 costs to 2008 costs
6. ITRC 2005 recommendation for O&M cost estimation

Table 6-3c

Water Treatment Plant Construction Calculations and Assumptions (8 cfs)

Design Flows: [1]		
Mill/Willow	**8 cfs**	**5 mgd**

Methodology and Assumptions:

Flow rate assumptions:[1]
Willow Creek annual average discharge of 7.88 cfs, all year

Capital costs estimated from costing data from EPA Guidance on arsenic treatment, based on 1 mgd (Table 3.4 in EPA 2002)

**These costs do not include any pretreatment or sludge management costs

Capital cost from EPA Guidance:		**1 mgd**
Precipitation/Coprecipitation (1998 dollars)	$	2,010,000
Escalation 1998 to 2008 (45%) [4]	$	2,900,000
Willow Creek:		**5 mgd**
Direct Scale Up	$	14,500,000
70% Scale Up	$	10,200,000
Municipal Water Treatment (e.g., Butte):		**2.7 mgd** [2]
Direct Scale Up	$	5,400,000
70% Scale Up	$	3,800,000

Notes:

1. Based on USGS annual average flow rate of 7.88 cfs
2. Municipal water supply assumed 80 gallons/day/person, Butte 2000 census 33,892 people.
3. cfs = cubic feet per second; mgd = million gallons per day.

Table 6-3c

Water Treatment Plant O&M Calculations and Assumptions (8 cfs)

Methodology and Assumptions:

Flow rate assumptions:[1]
Willow Creek = 8 cfs (5 MGD or 3,590 gpm), 12 months/year

Costs are based on CDM project specific experience managing the Summitville water treatment plant (1,100 gpm, 7 months/year, 2006 dollars)

These costs do NOT include utilities, pumping, etc. which would significantly increase the cost, particularly because of pumping large flow volumes

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no office hours. Scale up from 7 months to 12 for Willow Creek.

Hydrated Lime:	$	106.06	per ton, ECHOS - 2006
Ferric Chloride:	$	360.00	per ton - average cost, Internet search

Annual O&M Costs for Summitville Water Treatment Plant:

	1,100 gpm or 1.6 mgd			
	7 months		12 months scale-up	
Annual O&M (based on hours)	$	659,000	$	1,129,714
Lime Costs	$	96,000	$	164,571
Ferric Chloride	$	325,853	$	558,606
Total Annual (2006 dollars):	$	1,080,853	$	1,852,891
Escalation 2006 to 2008 (8%) [5]			**$**	**2,001,123**
$/kgal			*$*	*3.20*

Willow Creek Estimate:	**5 mgd**		**Comment:**
Annual O&M [2]	$	1,830,137	1.5x O&M Costs, 12 months
Lime Costs	$	-	No lime
Ferric Chloride	$	1,969,152	Direct Scale up
Total Annual:	**$**	**3,800,000**	
$/kgal [4]	***$***	***1.83***	

Notes:

1. See USGS hydrographs and text for discussion of selected flow rates.
2. There is not a one to one increase in O&M due to flow. Assumed 1.5 increase in shift size for the larger flow
3. cfs = cubic feet per second; mgd = million gallons per day, kgal = 1,000 gallons

Estimate cost of precipitation/coprecipitation treatment of water for arsenic contamination

Convert 15 cfs to gpm

ft3/sec x 7.48 gal/ft3 x 60 sec/min

6732 gpm See next tab for gallons per day required

Convert gpm to gpd

gal/min x 60 min/hr x 24 hr/min

9,694,080 million gal per day

Using costing data from EPA Guidance on arsenic treatment based on 1 mgd

These costs do not include any pretreatment or sludge management costs

	1 mgd	9.694 mgd
Capital costs:	$ 2,010,000	$ 19,485,101

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no Denver office hours. Scale up from 7 months to 12.

There is not a one to one increase in O&M due to flow. So, assume doubling shift size which roughly doubles hours for the bigger plant.

	1100 gpm	6732 gpm	
Annual O&M	$ 1,129,714	$ 2,259,429	
Lime Costs -	$ 164,571		
Ferric Chloride		$ 3,021,531	Directly scale up chemical costs using a 6/1 ratio and 3 times lime costs

Use a standard rate for domestic consumption to determine the amount of water needing treatment for drinking water

For domestic needs

1883 gpm required (based on Butte)

2,711,360 gallons per day

Scale up Captial costs:

	1 mgd	2.711 mgd
Capital costs:	$ 2,010,000	$ 5,449,834

	1100 gpm	1883 gpm	
Annual O&M - labor only	$ 1,129,714	$ 1,933,865	
Lime Costs -	$ 164,571		
Ferric chloride		$ 956,231	Use 3 x lime costs
Total O&M		$ 2,890,097	

Ferric chloride - $ 360.00 ton - average cost, internet search

Hydrated Lime $ 106.06 ECHOS - 2006

O&M Costs based on hydrated lime chemical supply.

Table 6-4c
Water Treatment Plant O&M Calculations and Assumptions (5 cfs)

Methodology and Assumptions:

Flow rate assumptions:[1]
Willow Creek = 5 cfs (3 MGD), 12 months/year

Costs are based on CDM project specific experience managing the Summitville water treatment plant (1,100 gpm, 7 months/year, 2006 dollars)

These costs do NOT include utilities, pumping, etc. which would significantly increase the cost, particularly because of pumping large flow volumes

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no office hours. Scale up from 7 months to 12 for Willow Creek.

Hydrated Lime:	$	106.06	per ton, ECHOS - 2006
Ferric Chloride:	$	360.00	per ton - average cost, Internet search, 2006

Annual O&M Costs for Summitville Water Treatment Plant:		**1,100 gpm or 1.6 mgd**		
		7 months		**12 months scale-up**
Annual O&M (based on hours)	$	659,000	$	1,129,714
Lime Costs	$	96,000	$	164,571
Ferric Chloride	$	325,853	$	558,606
Total Annual (2006 dollars):	$	1,080,853	$	1,852,891
Escalation 2006 to 2008 (8%) [5]			**$**	**2,001,123**
$/kgal			*$*	*3.20*

Willow Creek Estimate:		**3 mgd**	**Comment:**
Annual O&M [2]	$	1,830,137	1.5x O&M Costs, 12 months
Lime Costs	$	-	No lime
Ferric Chloride	$	1,230,720	Direct Scale up
Total Annual:	**$**	**3,100,000**	
$/kgal [4]	***$***	***2.63***	

Notes:

1. See USGS hydrographs and text for discussion of selected flow rates.
2. There is not a one to one increase in O&M due to flow. Assumed 1.5 increase in shift size for the larger flow
3. cfs = cubic feet per second; mgd = million gallons per day, kgal = 1,000 gallons
4. Typical water treatment O&M costs are often in the $1-$3 per 1,000 gallon range, this check seems reasonable.
4. Escalation factor from USACE Civil Works Construction Cost Index System (March 2008)

	Mill		Willow			Lost/Dutchman			
USGS "base flow"		15	3	18	cfs	1.5 to 40	cfs		
USGS Minimum Average Monthly Discharge		7.76	1.53	9.29	cfs	3.13	cfs		
USGS high flow - monthly		115	30.8	145.8	cfs	50	cfs	301	
USGS Annual Average Discharge		30	7.88	37.88	cfs	24	cfs	288	
Convert cfs to gpm									
ft3/sec x 7.48 gal/ft3 x 60 sec/min	low			8078.4	gpm	17952	gpm	1100	
	high			65435.04	gpm	22440	gpm		
Convert to MGD									
gpm x 60 min/hr x 24 hr/day/1000000	low			**11.6329**	mgd	25.85088	mgd	1.584	
	high			94.22646	mgd	**32.3136**	mgd		
So, say build Mill/Willow for 12 mgd				**12**	mgd	8333.333			
Lost for 30 mgd				**32**	mgd	22440			
Revise this assumption for Willow only			Use annual average discharge			8	cfs		
					base flow	3	cfs		
					high gpm	3590.4			
					low gpm	1346.4			
					high mgd	**5.170176**	**rounded**	**5**	mgd
					low mgd	**1.938816**		**2**	mgd

Design Flows	**Mill/Willow**	**5 mgd**
	Lost/Dutchman	**32 mgd**

Using costing data from EPA Guidance on arsenic treatment based on 1 mgd (Table 3.4 in EPA 2002)
These costs do not include any pretreatment or sludge management costs

		Mill/Willow	**Lost/Dutchman**	**Municipal Drinking Water (city size of Butte)**	
	1 mgd	**5 mgd**	**32.3136 mgd**	**2.711 mgd**	
Capital costs:	$ 2,010,000	$ 14,573,656	$ 64,950,336	$ 5,449,110	Direct Scale Up
escalation 1998-2000 (USACE)	0.450115039				
	$ 2,914,731				
		$ 7,035,000	$ 45,465,235	$ 3,814,377	70% cost scale up

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no Denver office hours. Scale up from 7 months to 12.
There is not a one to one increase in O&M due to flow. So, assume doubling shift size which roughly doubles hours for the bigger plant.

	1100 gpm	
Annual O&M	$ 1,129,714	
Lime Costs -	$ 164,571	
Ferric Chloride	$ 558,606	Directly scale up chemical costs on flow ratio and 3 times lime costs for ferric chloride

For Lost/Dutchman, don't scale up to 12 months - just assume 7 months is appropriate because flows decrease so much during irrigation

Ferric chloride -	$ 360.00	ton - average cost, internet search (thus about 3x lime costs)	
Hydrated Lime	$ 106.06	ECHOS - 2006	Escalate all by 1.08 for 2006 to 2008
		2006 numbers	

	Summitville		**Willow only**		**Lost/Dutchman**		**Municipal Drinking Water (**	
	1.6	**mgd**	**5**	**mgd**	**32.3136**	**mgd**	**2.711 mgd**	Lost/Dutchman scaled down to 7 months instead of 12
	1100	**gpm**	**3590**	**gpm**	**22440**	**gpm**	**1883 gpm**	
Annual O&M	$ 1,129,714		$ 1,830,137		$ 1,977,000		$ 1,933,751	Doubled and tripled O&M costs for larger plants, respectively
Lime Costs -	$ 164,571		$ -		$ -		$ -	NA - not liming the water, but base chemical cost on lime cost
Ferric Chloride	$ -		$ 1,969,152		$ 11,395,555		$ 956,175	Directly scale up chemical costs using a 6/1 ratio and 3 times lime costs
Total Annual O&M:	**$ 1,294,286**		**$ 3,799,289**		**$ 13,372,555**		**$ 2,889,926**	
$/gpm	$ 1,177		$ 1,058		$ 596		$ 1,535	

****IMPORTANT - These costs do NOT include utilities, pumping, etc. which would significantly increase the cost**

						Discount factor from EPA guidance at 7 percent
30 years present value		**$ 16,060,791**	**$ 47,145,378**	**$ 165,940,036**	**$ 35,861,094**	12.409
100 years present value		**$ 18,468,163**	**$ 54,212,056**	**$ 190,812,988**	**$ 41,236,357**	14.269
Total Capital+O&M		$ 18,070,791	$ 54,180,378	$ 211,405,271	$ 39,675,471	70% capital scale up + 30 years O&M
Range	to	$ 20,478,163	$ 68,785,712	$ 255,763,324	$ 46,685,467	Direct Scale up + 100 years O&M
			$ 61,719,034	$ 230,890,372		

Estimate cost of precipitation/coprecipitation treatment of water for arsenic contamination

Convert 15 cfs to gpm

ft3/sec x 7.48 gal/ft3 x 60 sec/min

6732 gpm See next tab for gallons per day required

Convert gpm to gpd

gal/min x 60 min/hr x 24 hr/min

9,694,080 million gal per day

Using costing data from EPA Guidance on arsenic treatment based on 1 mgd

These costs do not include any pretreatment or sludge management costs

	1 mgd	9.694 mgd
Capital costs:	$ 2,010,000	$ 19,485,101

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no Denver office hours. Scale up from 7 months to 12.

There is not a one to one increase in O&M due to flow. So, assume doubling shift size which roughly doubles hours for the bigger plant.

	1100 gpm	6732 gpm	
Annual O&M	$ 1,129,714	$ 2,259,429	
Lime Costs -	$ 164,571		
Ferric Chloride		$ 3,021,531	Directly scale up chemical costs using a 6/1 ratio and 3 times lime costs

Use a standard rate for domestic consumption to determine the amount of water needing treatment for drinking water

For domestic needs

1883 gpm required (based on Butte)

2,711,360 gallons per day

Scale up Captial costs:

	1 mgd	2.711 mgd
Capital costs:	$ 2,010,000	$ 5,449,834

	1100 gpm	1883 gpm	
Annual O&M - labor only	$ 1,129,714	$ 1,933,865	
Lime Costs -	$ 164,571		
Ferric chloride		$ 956,231	Use 3 x lime costs
Total O&M		$ 2,890,097	

Ferric chloride - $ 360.00 ton - average cost, internet search

Hydrated Lime $ 106.06 ECHOS - 2006

O&M Costs based on hydrated lime chemical supply.

Design Flows	**Mill/Willow**	**3 mgd**
	Lost/Dutchman	**32 mgd**

Using costing data from EPA Guidance on arsenic treatment based on 1 mgd (Table 3.4 in EPA 2002)
These costs do not include any pretreatment or sludge management costs

		Mill/Willow	**Lost/Dutchman**	**Municipal Drinking Water (city size of Butte)**	
	1 mgd	**3 mgd**	**32.3136 mgd**	**2.711 mgd**	
Capital costs:	$ 2,010,000	$ 8,744,194	$ 64,950,336	$ 5,449,110	Direct Scale Up
escalation 1998-2000 (USACE)	0.450115039				
	$ 2,914,731				
		$ 4,221,000	$ 45,465,235	$ 3,814,377	70% cost scale up

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no Denver office hours. Scale up from 7 months to 12.
There is not a one to one increase in O&M due to flow. So, assume doubling shift size which roughly doubles hours for the bigger plant.

	1100 gpm	
Annual O&M	$ 1,129,714	
Lime Costs -	$ 164,571	
Ferric Chloride	$ 558,606	Directly scale up chemical costs on flow ratio and 3 times lime costs for ferric chloride

For Lost/Dutchman, don't scale up to 12 months - just assume 7 months is appropriate because flows decrease so much during irrigation

Ferric chloride -	$ 360.00	ton - average cost, internet search (thus about 3x lime costs)	
Hydrated Lime	$ 106.06	ECHOS - 2006 2006 numbers	Escalate all by 1.08 for 2006 to 2008

	Summitville	**Willow only**	**Lost/Dutchman**	**Municipal Drinking Water (city**	Lost/Dutchman scaled down to 7 months instead of 12
	1.6 mgd	**3 mgd**	**32.3136 mgd**	**2.711 mgd**	
	1100 gpm	**2244 gpm**	**22440 gpm**	**1883 gpm**	
Annual O&M	$ 1,129,714	$ 1,830,137	$ 1,977,000	$ 1,933,751	Doubled and tripled O&M costs for larger plants, respectively, but also scaled Lost down for 7 months only
Lime Costs -	$ 164,571	$ -	$ -	$ -	NA - not liming the water, but base chemical cost on lime cost
Ferric Chloride	$ -	$ 1,230,720	$ 11,395,555	$ 956,175	Directly scale up chemical costs using a 6/1 ratio and 3 times lime costs
Total Annual O&M:	**$ 1,294,286**	**$ 3,060,857**	**$ 13,372,555**	**$ 2,889,926**	
$/gpm	$ 1,177	$ 1,364	$ 596	$ 1,535	

**IMPORTANT - These costs do NOT include utilities, pumping, etc. which would significantly increase the cost

					Discount factor from EPA guidance at 7 percent
30 years present value	**$ 16,060,791**	**$ 37,982,176**	**$ 165,940,036**	**$ 35,861,094**	12.409
100 years present value	**$ 18,468,163**	**$ 43,675,370**	**$ 190,812,988**	**$ 41,236,357**	14.269
Total Capital+O&M	$ 18,070,791	$ 42,203,176	$ 211,405,271	$ 39,675,471	70% capital scale up + 30 years O&M
Range to	$ 20,478,163	$ 52,419,564	$ 255,763,324	$ 46,685,467	Direct Scale up + 100 years O&M
		$ 46,726,369	$ 230,890,372		

Table 6-4c
Water Treatment Plant Construction Calculations and Assumptions (5 cfs)

Design Flows: [1]

Willow	**5 cfs**	**3 mgd**

Methodology and Assumptions:

Flow rate assumptions:[1] Based on approximate average ground water gain between upper and lower Willow Creek USGS monitoring stations during base flow.

Capital costs estimated from costing data from EPA Guidance on arsenic treatment, based on 1 mgd (Table 3.4 in EPA 2002)

**These costs do not include any pretreatment or sludge management costs

Capital cost from EPA Guidance:		**1 mgd**
Precipitation/Coprecipitation (1998 dollars)	$	2,010,000
Escalation 1998 to 2008 (45%) [4]	$	2,900,000
Willow Creek:		**3 mgd**
Direct Scale Up	$	8,700,000
70% Scale Up	$	6,100,000
Municipal Water Treatment (e.g., Butte):		**2.7 mgd** [2]
Direct Scale Up	$	5,400,000
70% Scale Up	$	3,800,000

Notes:

1. Based on USGS annual average flow rate of 7.88 cfs
2. Municipal water supply assumed 80 gallons/day/person, Butte 2000 census 33,892 people.
3. cfs = cubic feet per second; mgd = million gallons per day.
4. 2,010,000 escalated from 1998 dollars to 2008 dollars using USACE CWCCIS (2008)

Table 6-4c
Water Treatment Plant O&M Calculations and Assumptions
(5 cfs)

Methodology and Assumptions:

Flow rate assumptions:[1]
Willow Creek = 5 cfs (3 MGD), 12 months/year

Costs are based on CDM project specific experience managing the Summitville water treatment plant (1,100 gpm, 7 months/year, 2006 dollars)

These costs do NOT include utilities, pumping, etc. which would significantly increase the cost, particularly because of pumping large flow volumes

Using Summitville onsite loaded labor costs (includes OT) with no fee, no lab and no office hours. Scale up from 7 months to 12 for Willow Creek.

Hydrated Lime:	$	106.06	per ton, ECHOS - 2006
Ferric Chloride:	$	360.00	per ton - average cost, Internet search, 2006

Annual O&M Costs for Summitville Water Treatment Plant:	1,100 gpm or 1.6 mgd			
	7 months		12 months scale-up	
Annual O&M (based on hours)	$	659,000	$	1,129,714
Lime Costs	$	96,000	$	164,571
Ferric Chloride	$	325,853	$	558,606
Total Annual (2006 dollars):	$	1,080,853	$	1,852,891
Escalation 2006 to 2008 (8%) [5]			**$**	**2,001,123**
$/kgal			*$*	*3.20*

Willow Creek Estimate:	3 mgd		Comment:
Annual O&M [2]	$	1,830,137	1.5x O&M Costs, 12 months
Lime Costs	$	-	No lime
Ferric Chloride	$	1,230,720	Direct Scale up
Total Annual:	**$**	**3,100,000**	
$/kgal [4]	***$***	***2.63***	

Notes:

1. See USGS hydrographs and text for discussion of selected flow rates.
2. There is not a one to one increase in O&M due to flow. Assumed 1.5 increase in shift size for the larger flow
3. cfs = cubic feet per second; mgd = million gallons per day, kgal = 1,000 gallons
4. Typical water treatment O&M costs are often in the $1-$3 per 1,000 gallon range, this check seems reasonable.
4. Escalation factor from USACE Civil Works Construction Cost Index System (March 2008)